SIMULATION OF CASUALTY EVACUATION OF BRIGADE IN DEFENCE OPERATION

A THESIS
SUBMITTED TO THE DEPARTMENT OF INDUSTRIAL
ENGINEERING
AND THE INSTITUTE OF ENGINEERING AND SCIENCES
OF BILKENT UNIVERSITY
IN PARTIAL FULFILLMENT OF THE REQUIREMENTS
FOR THE DEGREE OF
MASTER OF SCIENCE

By
Özgür NUHUT
July, 2000

SIMULATION OF CASUALTY EVACUATION OF BRIGADE IN DEFENCE OPERATION

A THESIS

SUBMITTED TO THE DEPARTMENT OF INDUSTRIAL ENGINEERING

AND THE INSTITUTE OF ENGINEERING AND SCIENCES

OF BILKENT UNIVERSITY

IN PARTIAL FULFILLMENT OF THE REQUIREMENTS

FOR THE DEGREE OF

MASTER OF SCIENCE

By

Özgür NUHUT

July, 2000

I certify that I have read this thesis and that in my opinion it is fully adequate, in scope and in qualify, as a thesis for the degree of Master of Science

I. S.

Assoc. Prof. İhsan Sabuncuoğlu (Principal Adviser)

I certify that I have read this thesis and that in my opinion it is fully adequate, in scope and in qualify, as a thesis for the degree of Master of Science

Assoc. Prof. Osman Oğuz

I certify that I have read this thesis and that in my opinion it is fully adequate, in scope and in qualify, as a thesis for the degree of Master of Science

Assoc. Prof. Erdal Erel

Approved for the Institute of Engineering and Sciences

Prof. Mehmet Baray

Director of Institute of Engineering and Sciences

ABSTRACT

SIMULATION OF CASUALTY EVACUATION OF BRIGADE IN DEFENCE OPERATION

Özgür Nuhut

MS in Industrial Engineering

Supervisor: Assoc. Prof. İhsan Sabuncuoğlu

July, 2000

"The medical history of war casts light not only upon the suffering of those who fight but upon the dedication of those who save. Though the association between slaying and saving is paradoxical, it exists and helps to shape the nature of modern warfare—and of modern medicine as well."

—*The Medics' War, Albert E. Cowdrey, Washington, D.C., 24 March 1986*

We analyze a simulation model which is not currently available in Turkish Land Forces, and which has not been examined in field-exercises. By making such a simulation we give some useful and important statistical information about casualties such as time in first aid stations and hospitals, waiting times in doctors' queues, utilization of doctors, number of patients according to their sickness categories, percentages of casualties that return to duty, died or send to higher level medical centers to the commanders of units, to the logistical commanders and to the medical commanders to help them in deciding on true alternatives or solutions.

The result of thesis indicates that there are significant bottlenecks in brigade separate station and in 30-bed hospital, especially in queues of sections' wards. In addition, we observed that if the number of casualties entering the system increases by 3 times, there will be bottlenecks in the queues of battalions' doctors and in the queues of 30-bed hospital normal surgery section's operator.

ÖZET

SAVUNMA HAREKATINDA TUGAY SIHHİ TAHLİYE SİSTEMİNİN SİMULASYONU

Özgür Nuhut

Endüstri Mühendisliği Bölümü

Danışman: Doçent Dr. İhsan Sabuncuoğlu

Temmuz, 2000

"Savaşın tıbbi tarihçesi sadece savaşanların acısına değil, fakat hayat kurtaranların fedakarlığına da ışık tutar. Öldürmek ve hayat kurtarmak arasında bir ilişki kurmak tezat teşkil etse de bu durum gerçektir ve modern savaşın doğasını şekillendirdiği gibi modern tıbbinkini de şekillendirir."

—*The Medics' War, Albert E. Cowdrey, Washington, D.C., 24 Mart 1986*

Biz, halihazırda Türk Kara Kuvvetlerinde olmayan ve arazi tatbikatı yapılmamış bir simulasyon modelinin analizini yaptık. Böyle bir simulasyon yaparak, birlik komutanlarına, lojistikle ilgili komutanlara ve sağlık sisteminin ilgili komutanlarına doğru alternatifler ve çözümler üzerinde doğru karar vermelerine yardımcı olacak, zayiatların doktor kuyruklarında bekleme süreleri, doktorların performansları, göreve dönen, ölen ya da tedavisi süren zayiatların oranları gibi yararlı ve çok önemli istatistiksel bilgiler verdik.

Tezin sonucu gösterdi ki, tugay ayırma istasyonunda ve tugay 30-yataklı cerrahi hastanelerinde, özellikle yatakhanelerin kuyruklarında çok ciddi sorunlar mevcuttur. Buna ek olarak, yaralı sayısını üç kat artırırsak, tabur doktorlarının kuyruklarında ve 30-yataklı hastanelerin normal ameliyat operatörlerinin kuyruklarında sorunlar olacağını gözlemledik.

Contents

LIST OF PICTURES

LIST OF TABLES

Number **Page**

LIST OF FIGURES

Number **Page**

To my wife, Zahide and daughter, Didem,

for their encouragement, kindness,

affectionate and understanding

ACKNOWLEDGMENTS

I would like to express my sincere gratitude to Assoc. Prof. İhsan Sabuncuoğlu for his supervision and encouragement during my graduate study. He has been so kind and patient in all my desperate times. His trust and understanding motivated me and let this thesis come to an end.

I am grateful to Dr. Osman Oğuz and Dr. Erdal Erel for their suggestions for my thesis work and for reading and reviewing my thesis.

I would like to take this opportunity to thank Assoc. Prof. İhsan Sabuncuoğlu, Barbaros Tansel, Vladimir Anisimov, Ömer Benli, Oya Karaşan, Osman Oğuz, and Mustafa Akgül for their contribution to my knowledge treasure and inserting a science bank in my brain as being such kind and understanding instructers. I am grateful to my friends Olcayto Çandar, Hakan Utku, Ali Tütüncüoğlu, Serdar Yavuz, Muhittin Demir, Gonca Yıldırım, Pelin Arun, Banu Yüksel and Mümin Kurtuluş for all their friendship, support, encouragement and all the nice times we spent together. I also would like to thank to Yeşim Karadeniz for her understanding and support.

GLOSSARY

Patient Evacuation

Patient evacuation is the timely and efficient movement of wounded, injured, or ill persons from the battlefield and other locations to the Medical Treatment Facilities. Evacuation begins at the location where the injury or illness occurs and continues as far as the patient's medical condition warrants or the military situation requires. Medical personnel provide en route medical care during patient evacuation.

Casualty

A casualty is any person who is lost to the organization because of having been declared wounded, injured, and diseased.

1. Battle Casualty

A battle casualty is any casualty incurred in action

Battle casualties include the following:

a. Wounded in Action

This term describes a battle casualty who has incurred an injury due to an external agent or cause. The term WIA covers all wounds and other injuries incurred inaction whether there is piercing of the body, as in a penetrating or perforating wound, or none, as in the contused wound; all fractures, burns, blast concussion; all effects of biological and chemical warfare agents; and the effects of exposure to ionizing radiation, or any other destructive weapon or agent.

b. Nonbattle Casualty

Nonbattle casualty describes a person who is not a battle casualty, but who is lost to his organization by reason of disease or injury, including persons dying from disease or injury.

c. Patient

Patient is the generic term applying to a sick, injured, or wounded person who receives medical care or treatment from medically trained personnel who make medically substantiated decisions based on medical military occupational specialty (MOS) specific training. A patient may be further classified as an outpatient or an in-patient.

(1). Outpatient: Outpatient is the term applied to a person receiving medical/dental examination and/or treatment from medical personnel and in a status other than being admitted to a hospital. Included in this category is the person who is treated and retained (held) in an MTF other than a hospital.

(2). In-patient: In-patient is the term applied to a person admitted to and treated within a hospital and who cannot be returned to duty within the same calendar day.

Medical Treatment Facility (MTF)

The term, medical treatment facility denotes a facility established for purpose of providing health services to authorized personnel. It may be but is not limited to an aid station, area support section (clearing station), a clinic, a dispensary, or a hospital.

The Theater Evacuation Policy

Evacuation policy is established by the Secretary of Defence, with the advice of Chief of the General Staff, and upon the recommendation of the theater commander. The policy establishes, in number of days, the maximum period of noneffectiveness (hospitalization and convalescence) that patients may be held within the theater for treatment. This policy does not mean that a patient will be held in the theater for the entire period of noneffectiveness. A patient who is not expected to be ready for returning to duty within the number of days established in the theater evacuation policy is evacuated to higher level health centers or finally rehabilitation center.

HSS (Health Support and Service)

The HSS mission--to conserve the fighting strength--dictates that patients be collected, triaged, treated, and returned to duty as far forward as possible.

The multifunctional HSS system operates as a single integrated system that extends from the forward areas of the CZ to the zone of interior (ZI).

Advanced Trauma Management (ATM)

Advanced trauma management is physician directed emergency medical care designed to resuscitate and stabilize the patient for evacuation to the next level of medical care, or to treat and RTD. Advanced trauma management provides maximum benefit if received within 60 minutes of injury.

Theater of Operations

A TO is that portion of an area of conflict including land, sea, and air masses necessary for military operations and the administration incident to such operations. The theater is normally divided into two major zones: the CZ (Combat Zone) and the COMMZ (Communication Zone).

Defence

The immediate purpose of a defence is to defeat an enemy attack. Brigades perform a variety of operations in support of a division, corps, or army-level defence. The brigade conducts defensive operations to defeat an enemy attack, gain time, concentrate forces elsewhere, control key or decisive terrain, attrite enemy forces, or to retain tactical objectives. The ultimate purpose is to create conditions favourable to assuming the offence. Future battlefields may be noncontiguous. Brigades are bypassed, penetrated, or encircled without loss of overall defensive integrity, but a penetration that threatens the integrity of the defence must be avoided. Brigade defences combine fires, obstacles, and maneuver to create and exploit the exposed flank and rear of the enemy. The brigade uses existing and reinforcing obstacles to disrupt, turn, fix, or block the enemy attack. The enemy is forced onto unfavorable terrain where he receives destructive fires from mutually supporting positions. Additional battalions attack the depth of the enemy. Indirect fires delay and weaken enemy forces, causing them to change avenues of approach, and limit their ability to resupply and reinforce committed forces. Smoke masks friendly locations, isolates enemy echelons, degrades the enemy's target acquisition, and further slows enemy maneuver.

Battalion Task Force

Tank and mechanized infantry battalion task forces are organized to fight and win engagements on any part of the battlefield in conventional, nuclear, or chemical environments. They combine the efforts of their company teams and combat support to perform tactical missions as part of a brigade operation. The key to victory is to quickly mass the combat power of maneuver company teams and integrate and synchronize combat support (CS) and combat service support (CSS) combat multipliers.

Military Words' Turkish Meanings

Army: Ordu, involves approximately 9 brigades. Its commander is full-general.

Corps: Kolordu, involves approximately 3 brigades. Its commander is lieutenant general.

Brigade: Tugay, involves approximately 3 battalion task forces and 6000 soldiers. Its commander is brigadier general.

Battalion: Tabur, involves approximately 3 company teams. Its commander is lieutenant colonel.

Company: Bölük, involves approximately 4 platoons. Its commander is captain.

Platoon: Takım, involves approximately 50 persons. Its commander is first lieutenant or second lieutenant.

Headquarter Company: **Karargah Bölüğü**, Its commander is captain.

Tank Company: **Tank Bölüğü,** involves approximately 3 tank platoons. Its commander is a captain.

Artillery Battery: **Topçu Bataryası,** involves approximately 2 artillery sections. Its commander is a captain.

Engineer Company: **İstihkam Bölüğü,** Its commander is a captain.

Air Defence Company: **Hava Savunma Bölüğü,** Its commander is a captain.

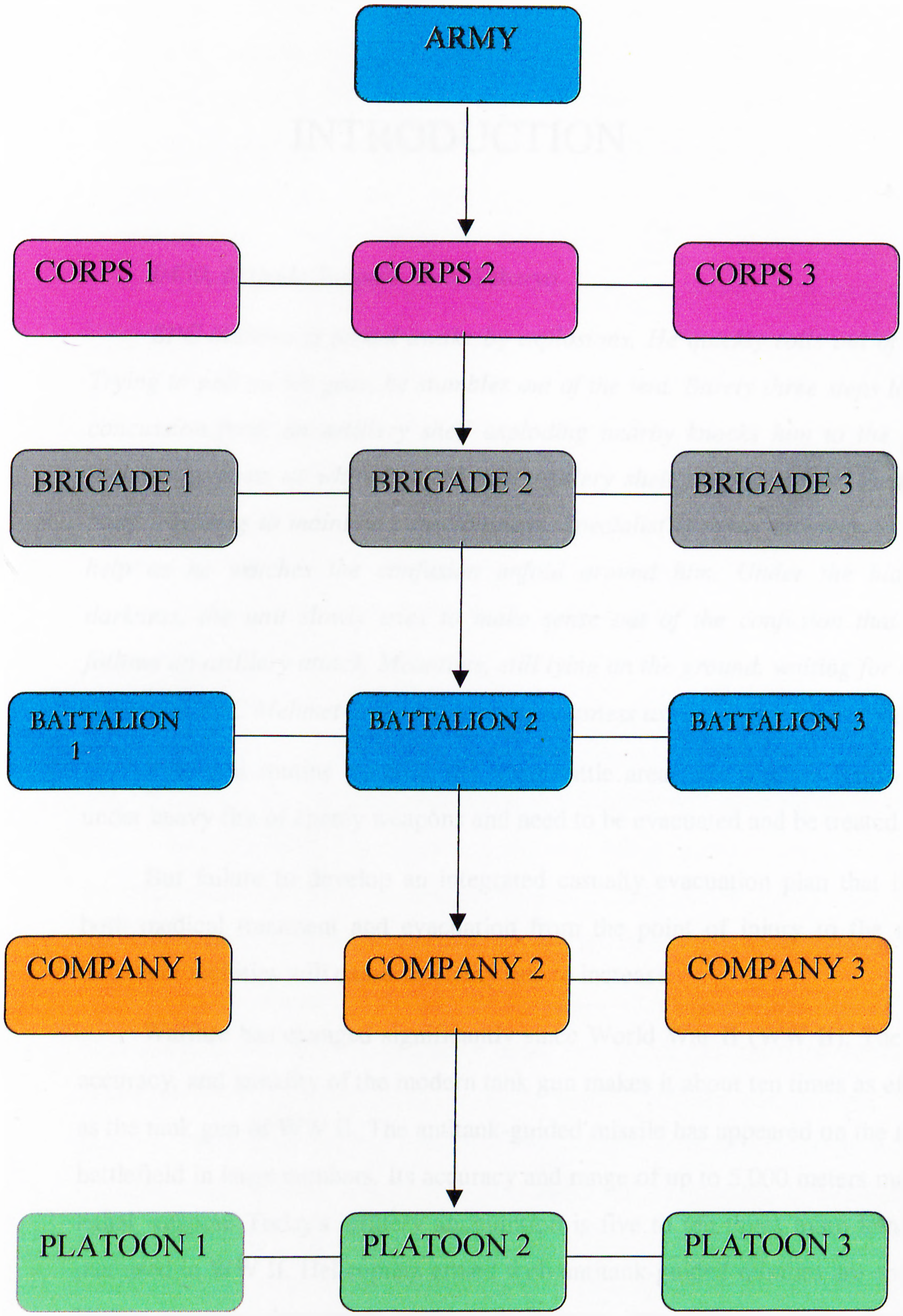
Ordnance Company: **Ordudonatım Bölüğü,** Its commander is a captain.

Tow Platoon: **Tow Takımı,** Its commander is first lieutenant or second lieutenant.

In Picture A, we give a general picture of the army organization.

PICTURE A

TURKISH ARMY ORGANIZATION



CHAPTER 1

INTRODUCTION

0430, Brigade Support Area, Sakarya

SPC Mehmet is jerked awake by explosions. He quickly rolls out of his cot. Trying to pull on his gear, he stumbles out of the tent. Barely three steps later, the concussion from an artillery shell exploding nearby knocks him to the ground. Mehmet screams as white-hot 155-mm artillery shell fragments tear through his body. Fighting to maintain consciousness, Specialist Mehmet attempts to call for help as he watches the confusion unfold around him. Under the blanket of darkness, the unit slowly tries to make sense out of the confusion that always follows an artillery attack. Meantime, still lying on the ground, waiting for medical treatment, SPC Mehmet drifts into unconsciousness as life slips from his body.

This is a routine event at the main battle area. The soldiers get wounded under heavy fire of enemy weapons and need to be evacuated and be treated.

But failure to develop an integrated casualty evacuation plan that includes both medical treatment and evacuation from the point of injury to the medical treatment facilities will cause mortality rate to increase.

Warfare has changed significantly since World War II (WW II). The range, accuracy, and lethality of the modern tank gun makes it about ten times as effective as the tank gun of WW II. The antitank-guided missile has appeared on the modern battlefield in large numbers. Its accuracy and range of up to 5,000 meters make it a lethal weapon. Today's artillery ammunition is five to ten times more lethal than that used in WW II. Helicopters armed with antitank-guided missiles are common. Highly accurate, long-range mobile air defence gun missile systems have also appeared in great numbers to dominate the space above the battlefield. The long-range, high-velocity tank cannon and long-range antitank missile systems control the modern battlefield. With this sophisticated weaponry, anything that can be seen can be hit and killed. Fighting future engagements on a non-linear, expanded battlefield demands changes in the delivery of Combat Help Support. Changes in CHS doctrine must address the requirements for force projection, as well as the future at the field characteristics of dispersion, lightning-quick military operations, increased mobility, rapid task organization, and lengthened lines of communications. These make the battlefield more lethal than ever. As the battlefield becomes increasingly lethal, sustaining the health of the fighting forces becomes a critical factor in the success or failure of the mission. Comprehensive planning enhances the capability of medical units to provide effective HSS (Health Support and Service) and ultimately increases the chances for survival of the wounded soldier. Forward support characterizes the role that HSS must assume. The thrust of HSS is to maximize the RTD (return to duty) rate. This conserves the human component of the tactical commander's weapons system. All leaders must understand that taking care of the unit's casualty will help build unit morale and confidence in the chain of command. Our soldiers will do anything their leaders ask if they know that the unit will do everything in its power to help them in the event they become casualties. However, if commanders allow the trend of a great percent died of wounds rates to continue, our soldiers will question the sincerity of leaders who talk about taking care of soldiers. All leaders also must know that in the initial phases of battle, the soldiers who are treated and returned to duty provide the tactical commanders with the only source of trained combat replacements.

We have chosen this subject to develop a simulation model which has not been made before in Turkish Land Forces and which has not been examined in field-exercises. The first objective is to model, analyze the existing Brigade casualty evacuation system and improve patient flow processes in the main facilities of the system. This model will allow the comparison of alternatives as well as providing a tool for evaluating the impact of alternative system designs. Second purpose is to make a comparison of existing system with proposed new system to find the best system. The third objective is to propose some additional alternative systems to alleviate the problems in the existing system.

This study also presents simulation modelling as a decision support technique and suggests that it can be a useful for understanding problems related to casualty evacuation. The study shows that simulation may not be regarded as a tool for deriving solutions to certain problems. In fact simulation is better suited for understanding the problem and enhancing systematic debate between the problem owners. By making such a simulation, we can give some useful and important statistical results about casualty evacuation system to unit commanders, to logistical commanders and to medical commanders to support them in deciding on true alternatives or solutions. This information may include time in any of medical treatment facilities, waiting time in any of queues, utilization of resources, number of patients according to their sickness categories, percentages of patients that return to duty, dye or that are sent to higher level medical centers. Our purpose is to determine certain problem areas with certain numerical information to take efficient precautions against them on time via simulation. Because the most important resource is the time in a war and with these informations, we hope to achieve the following:

1. A Health Support and Service (HSS) planner can compute the beds required in the theater. This can be translated into the type, mix, number, and distribution of hospitals required in the theater.

2. A non-medical logistician can estimate his total obligation to support this system.

3. An HSS operator will have a management tool, simulation results, which when properly adjusted and used, will provide the balance between patient care and tactical support requirements. The HSS operator will be able to tailor a HSS package specifically designed to handle patient workloads, with maximum benefit to the patients and with maximum economy of available resources.

Over the past four decades, simulation has proven to be an important tool in the analysis of a wide variety of health care delivery systems. Over 30 years ago, Fetter and Thompson (1965) as well as Robinson, Wing, and Davis (1968), applied simulation to patient scheduling and other hospital operational problems. Several characteristics of simulation make this technology uniquely applicable in the health care arena.

Simulation has many advantages over more traditional approaches to process improvement in casualty evacuation. It provides an objective way to test different alternative processes. Simulation also delivers a quantified difference between the different alternatives. Simulation is not emotional and has no territorial urges. Simulation shows how a change in one area of a medical treatment facility will affect operations in other areas. Simulation is useful in verifying the architectural design for a new construction project. Plans can be tested and modified prior to final approval (Banks, 1998)

In this study, simulation is used to analyze the behaviour of the Mechanized Infantry Brigade's casualty evacuation in defence operation. The simulation was conducted using ARENA 3.0 Simulation Software Package. Developing weapon, communication and transportation technologies force the war to be ended in a few days. Huge economical damage of war forces the nations not to make war. But if it is inevitable they want to finish the war in a few days. For this reason we take period as 10-day period.

This system is terminating system. Because there is a natural event E that specifies the length of each run. The goal of this simulation is to determine the final casualty numbers according to their types, procedure and system times of medical treatment facilities and medical persons when the battle ends. In this case E = {either the blue force or the red force has "won" the battle} (Law and Kelton, 1991).

A brief review of relevant literature is given in Chapter 2. In Chapter 3 the analysis of the brigade casualty evacuation system is explained in detail. The analysis of simulation model of casualty evacuation of brigade in defence operation is explained in Chapter 4. First, the simulation model is explained in detail. Conceptual model of the simulation model and logical model of the simulation is explained. The collection of necessary data for simulation study is explained. The model is verified and validated. Finally, the output analysis is performed. In output analysis determination of run length is explained, since the simulated system is terminating system. In chapter 5, the simulation experiments performed are discussed to see the improvements the alternative system designs, to make comparisons of existing system with proposed systems and to make comparison among alternative system designs. In Chapter 6, the results of the simulation study are presented and possible subjects for further study are suggested.

CHAPTER 2

LITERATURE REVIEW

Simulation is an ideal tool for addressing wide ranging issues in health care delivery. These issues involve public policy, patient treatment procedures, capital expenditure requirements, and provider operating policies.

Today, researchers and analysts are beginning to uncover the potential for using simulation in the health care field; with a multitude of interactions between patients, physicians, nurses, and technical and support staff, simulation can be an invaluable tool. Inefficiencies can be eliminated or resource allocation changed to determine an optimal setup. Primarily, simulation has been used in the health care field in comparison studies of alternative systems for resource or scheduling requirements (Lowery, 1998). When analyzing such alternatives, the standard performance measures are typically reported: throughput, time in system, and queue times and lengths.

While doing literature review we have seen that there are studies in health care area, <u>but there is no study like we do, involving all steps of evacuation and treatment through a chain of medical treatment facilities.</u> There is the commercial computerized simulation software called MEDIC-1. It provides physicians, paramedics, nurses, and emergency medical technicians. We couldn't get a rich information about it because of its being commercial. There are also some studies in the USA army, but it is forbidden to enter these studies' web pages. For this reason, here we will represent researches that are in the health care area.

Publication	Subject
W. H. Iskander (1989)	simulation model providing emergency medical service systems
A. P. Kumar R. Kapur (1989)	Simulation analysis of the Emergency Room at Georgetown University Hospital
J. C. Lowery (1992)	GPSS/H model to simulate the flow of patients through a hospital's critical care units
R. L. Wears C. N. Winton (1993)	Combined discrete-continuous simulation model focusing on trauma care and implemented in SIMSCRIPT II
F. McGuire (1994)	Used simulation to reduce length of stay in emergency departments
S. C. Sundstrom S. A. Matheny C. G. Blood (1996)	optimal number and positioning of patient evacuation assets within a theater of operations
J. C. Lowery J. A. Davis (1999)	Renovation Brigham and Women's Hospital's existing surgical suite to accommodate primarily impatient cases
W. Cahill M. Render (1999)	dynamic simulation model of intensive care unit bed availability
J. A. Sepulveda W. J. Thompson F. F. Baesler M. I. Alvarez (1999)	Used simulation for process improvement in a cancer treatment center

Table 1. Summary of Literature Review

is given in Table 1, Scott C. Sundstrom, Christopher G. Blood and Serge A. Matheny (1996) tried to determine optimal number and positioning of patient evacuation assets within a theater of operations by using linear programming. They explained that through the use of linear programming techniques, the optimal number and positioning of patient evacuation assets within a theater of operations may be determined to ensure the orderly transport of casualties from the front lines to third level medical treatment facilities. The Probabilistic Location Set Covering Problem has been chosen as the core module for a linear programming model to assist in these determinations. The Optimal Placement of Casualty Evacuation Assets (OPTEVAC) model prompts the user to enter the dimensions of the theater, troop deployment nodes, types of evacuation assets available, and preferred locations of medical treatment facilities. The OPTEVAC model then provides output as to the required numbers of ground and air ambulances as well as the optimal positioning of those evacuation assets (Blood and Matheny, 1996).

Wafik H. Iskander (1989) developed a simulation model providing emergency medical service systems planners and managers with help in the planning of their operations and in their decision making role in general.Several simulation models were developed earlier in the area of Emergency Medical Services. Savas (1968) used a simulation modeling approach to analyze proposed changes in the number and locations of ambulances in the city of New York. Seiler (1971). And Baker (1978) concentrated their effort on the location of Emergency Medical Service squads in urban and rural areas, respectively, in order to minimize the ambulance response time. Gochenour (1972), Okeugo (1981), and Currie, et al. (1984) developed simulation models that are more general in nature.Iskander's model was developed using FORTRAN and SLAM II (Pritsker, 1986). The events identified for the model were, arrival of a call, end of service at the hospital and arrival at base. The model was successfully tested on one of the seven EMS regions in the state of West Virginia. Outputs were produced under the normal rate of calls as well as increased and reduced rates. The outputs produced helped answer questions on the elimination and addition of squads, reallocation of vehicles, and appropriate level of personnel training (Iskander, 1989).

Arvind p. Kumar and Rajiv Kapur (1989) present the simulation analysis of the Emergency Room at Georgetown University Hospital, using a unique approach to schedule nursing staff. The simulation was conducted using SIMAN. The first 120 hours of the simulation run were ignored to allow the system to reach steady state. Upon arrival the patients were assigned an acuity, triaged and based on acuity sent either directly to the treatment area or to registreation and then treatment.Outputs from the simulation runs included patient waiting time, average nurse utilization and average number of patients waiting in the waiting area of the treatment area. Simulations were run with the alternative schedules input into the model. Nine schedules were examined and simulated. Of the nine, two were selected as feasible schedules in terms of affect on patient wait times and their cost effectiveness (Kumar and Kapur, 1989).

Julie C. Lowery (1992) developed a GPSS/H model to simulate the flow of patients through a hospital's critical care units, including the operating room, post anesthesia recovery unit, surgical intensive care unit, intermediate surgical care unit, coronary care unit, intermediate coronary care unit, telemetry unit, medical intensive care unit and ventilator unit. The objective of the study was to design and implement a simulation model of a large, tertiary care community hospital's surgical suite and critical care area, for the purpose of assisting hospital management in determining critical care bed requirements.The simulation model is designed to represent the arrival of patients to, and their flows through, nine different units in study hospital that are mentioned above. The simulation model includes both random and scheduled arrivals. Unfortunately, it was difficult for the hospital staff to reach a conclusion, because an acceptable level of turnaways was never explicitly stated. Nevertheless, the output did provide information which helped hospital staff better understand the occupancy-turnaway tradeoff, which, in turn, could help them make an informed decision regarding critical care bed requirements. At the completion of the funding period, a final decision on the number and types of beds to add had not been made (Lowery, 1992).

Robert L. Wears and Charles N. Winton (1993) designed a combined discrete-continuous simulation model focusing on trauma care and implemented in SIMSCRIPT II. 5 to allow prediction of the effect of policy changes on system performance and patient survival. The system can be decomposed into five fundamental elements: Patients, vehicles, receiving facilities, injuring events and a transportation network over which vehicles move patients from sites of injury to or between receiving facilities. A s a conclusion they determine that the trauma triage cutoff, which has been the subject of vehement debate at times, had little effect on the overall load on the system, while a factor that has received little attention, the retriaging of less severely injured patients to a higher level of care if such a center is reasonably "close" had a much greater impact. This leads to the conclusion that the common knowledge of domain experts may not always be helpful in predicting the response of a complex system to change, and that computer models of such systems may enhance the decision makers accuracy and reliability by adding insight into the possible responses of the system to variables that were not previously thought important (Wears and Winton, 1993).

Frank McGuire (1994) used simulation to reduce length of stay in emergency departments. The object of the simulation study was a medium to large sized hospital in the southeast of the USA. Faced with an increasing number of patient complaints about long waiting times, the hospital decided to take action and chosed simulation as a tool for evaluation of alternative courses of action. The emergency department has 18 examination rooms, two of which are designated as trauma rooms, ane as a psychiatric room, ane as a muscular/skeletal room, one as an eye, ear, nose, and throat room and one as an operation room. There is also a fast track area (4 rooms) for lower acuity patients, a clinic (4 rooms) for low acuity pediatric patients. The simulation software chosen for the project was MedModel, a healthcare industry-specific simulator package produced by PROMODEL Corporation. Five alternatives were tested for effectiveness with the simulation model. Adjustments were made with each alternative, and a combination of the most effective changes was suggested to the hospital's executive management. One of the predetermined alternatives was the addition of a registration clerk during the peak hours of the day. There was no significant improvement in the patient's length of stay by adding a registration clerk. A second alternative chosen early was to extend the hours of operation of the fast-track and pediatric clinic hours of operation.This alternative reduced the length of stay for all patients by 16 minutes. A third alternative chosen prior to the model construction was to see what the impact on patient's length of stay would be if the ancillary departments could meet comparative times for turnaround times.The impact of reducing the turn time to 45 minutes would be a savings of 24 minutes for the average patient. If a holding area is available for the admitted patients the treatment rooms could be used by waiting patients. The simulation showed that an average of 22 minutes per patient could be saved by using 4 rooms divided by a curtain to accommodate a total of 8 patients.Finally, using emergency department physicians instead of residents reduced the length of stay by 14 minutes in the fast-track area. An alternative was added that uses similar criteria for both areas and emergency department physicians instead of residents in the fast-track area. The average length of stay for all patients in the emergency services area was reduced by 50 minutes to 107 minutes. This was well below the acceptable average of 120 minutes (McGuire, 1994).

Julie C. Lowery and Jennifer A. Davis (1999), in 1997 Brigham and Women's Hospital (BWH) in Boston, initiated a construction project to renovate its existing surgical suite to accommodate primarily in-patient cases. The new in-patient suite would include 32 operating rooms, which was two less than the number of rooms in the suite prior to renovation. BWH administrators, planners, and clinicians wanted to be sure that the 32 rooms would be sufficient. In addition, they wanted to examine the possible effects of changes in the surgical schedule and in case times on the number of rooms required. They selected simulation as the methodology for investigating these issues. The model was developed using MedModel simulation software the resultant model includes a number of assumptions that simplified model construction, yet still resulted in a valid model that met project objectives. The model showed that the projected changes in surgical workload could be accommodated in 30 operating rooms (or fewer) if scheduled block time were extended during the weekdays and Saturday blocks were added (Lowery and Davis, 1999).

William Cahill and Marta Render (1999) made a dynamic simulation model of intensive care unit (ICU) bed availability in their study. For this purpose they chose the Cincinnati VA Medical Center as study area. The Cincinnati VA Medical Center is an acute care, university affiliated 220-bed facility serving eligible veterans with medical, surgical, neurological and psychiatric care needs. ICU beds are unavailable nearly one third of the time, eliminating new ICU admissions, and requiring diversion of ambulance traffic. Diverting ambulance traffic adversely impacts patient satisfaction and community perception of quality of care delivered at this center. Phased construction to relieve the problem was planned, including additional telemetry beds, move of ventilator dependent patients out of the ICU to a Respiratory Care Unit (Tele/RCU), and development of ICU swing beds in the emergency room area (Heart ER). They assessed the likelihood that the planned changes would result in the desired outcomes. A computer model representing medical bed utilization at this facility was developed using dynamic simulation software Arena. This model analyzed the flow of patients through the ICU, telemetry and medical floor beds under current bed allocation. The model demonstrated improved availability of ICU beds with the addition of the telemetry and respiratory care unit beds. Unexpectedly, increased ICU bed availability resulted in increased telemetry and medical floor bed utilization downstream and increased length of stay on the medical service as the proportion of post-ICU patients increased on the floors. Modelling in advance of the renovation provided an opportunity to develop length of stay reduction strategies to meet the floor bed needs (Cahill and Render, 1999).

José A. Sepúlveda, William J. Thompson, Felipe F. Baesler and María I. Alvarez (1999) used simulation for process improvement in a cancer treatment center. The objective was to analyze patient flow throughout the unit, evaluate the impact of alternative floor layouts, using different scheduling options and to analyze resources and patient flow requirements of a new building simulation model for both practices using ARENA. This paper focuses on three major analyses performed. 1. Layout Scenario. 2. Scheduling Alternatives Scenario. 3. New Building Scenario. The first scenario is related to a major layout change proposed for the existing cancer treatment center. The second scenario focused on finding alternative patients' arrival schedules in order to obtained a better utilization of hospital resources. The last scenario transferred the results for the existing facility to simulate and analyze the impact of a future building where the cancer treatment center was to be integrated with radiation oncology and in-patient care. This paper shows how decision making in a cancer treatment center or any health care facility can be facilitated using simulation. The results obtained from this analysis showed that important improvements in patients' flow time could be achieved. This analysis showed that the number of patients seen per day could be increased up to a 20% without materially affecting the closing time of the facility. A second simulation model was developed to analyze a new building where the center was to be moved. This building was designed for a capacity of over 100% of that existing today. The results showed that one of the waiting rooms did not have sufficient capacity to support the flow of patients. In addition to these results all the simulated scenarios were used to identify bottlenecks and to analyze patient flow and operating efficiency (Sepulveda, Thompson, Baesler and Alvarez, 1999).

CHAPTER 3

THE PROBLEM DEFINITION AND SYSTEM DESCRIPTION

3.1. General

In this study we develop the simulation model of casualty evacuation of brigade in defence operation under war conditions.

Patient evacuation is the timely and efficient movement of wounded, injured, or ill persons from the battlefield and other locations to the medical treatment facilities. Evacuation begins at the location where the injury or illness occurs and continues as far as the patient's medical condition warrants or the military situation requires. Medical personnel provide en route medical care during patient evacuation.

For medical evacuation, the gaining unit is responsible for arranging for the evacuation of patients from lower echelons of care. For example, Echelon II medical units (brigade units) are responsible for evacuating patients from Echelon I (battalion units) medical units.

Medical evacuation encompasses:

- Collecting the wounded.
- Sorting (triage).
- Providing an evacuation mode (transport).
- Providing medical care en route.

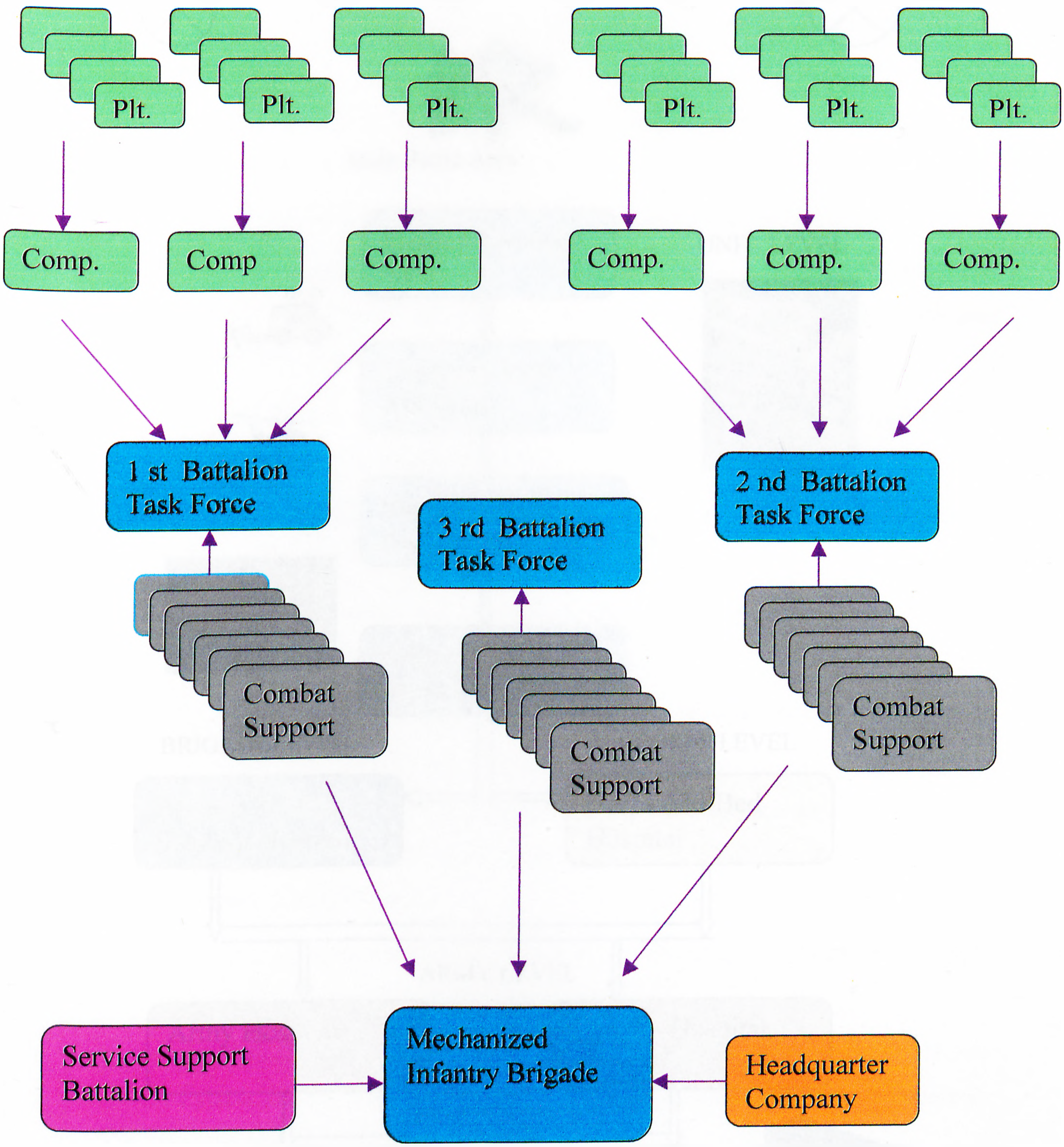
The Secretary of Defence establishes evacuation policy, with the advice of the Chief of Staff, and upon the recommendation of the theater commander. The policy establishes, in number of days, the maximum period of noneffectiveness (hospitalization and convalescence) that patients may be held within the theater for treatment. This policy does not mean that a patient will be held in the theater for the entire period of noneffectiveness. A patient who is not expected to be ready for returning to duty within the number of days established in the theater evacuation policy is evacuated to higher level health centers or finally rehabilitation center. This is 1 to 6 hours for battalion, 3 days for brigade separate station, 3 days for Brigade 30-bed hospital, 7 days for Corps 600 Bed Hospital, 10 days for Army Hospital and no limit for Rehabilitation center.

The multifunctional HSS system operates as a single integrated system that extends from the forward areas of the CZ to the zone of interior (ZI). This system is dependent upon effective medical regulating and the evacuation of sick, injured, and wounded soldiers in the shortest possible time. (See Picture B)

The commander's casualty plan must start with immediate treatment at the point of injury. When a casualty occurs during a conflict, the first soldier on the scene to render assistance is normally the casualty's fighting position buddy. It is this soldier's responsibility to start the treatment process by conducting buddy aid at the point of injury. The unit must understand that this initial treatment is the first building block in a successful company medical plan. Depending on the nature of the attack, the unit may not be in a position to provide additional medical attention to the casualty for a prolonged period of time. The company commander must ensure all soldiers are trained to execute at least the first aid tasks. (See Picture B and Picture C)

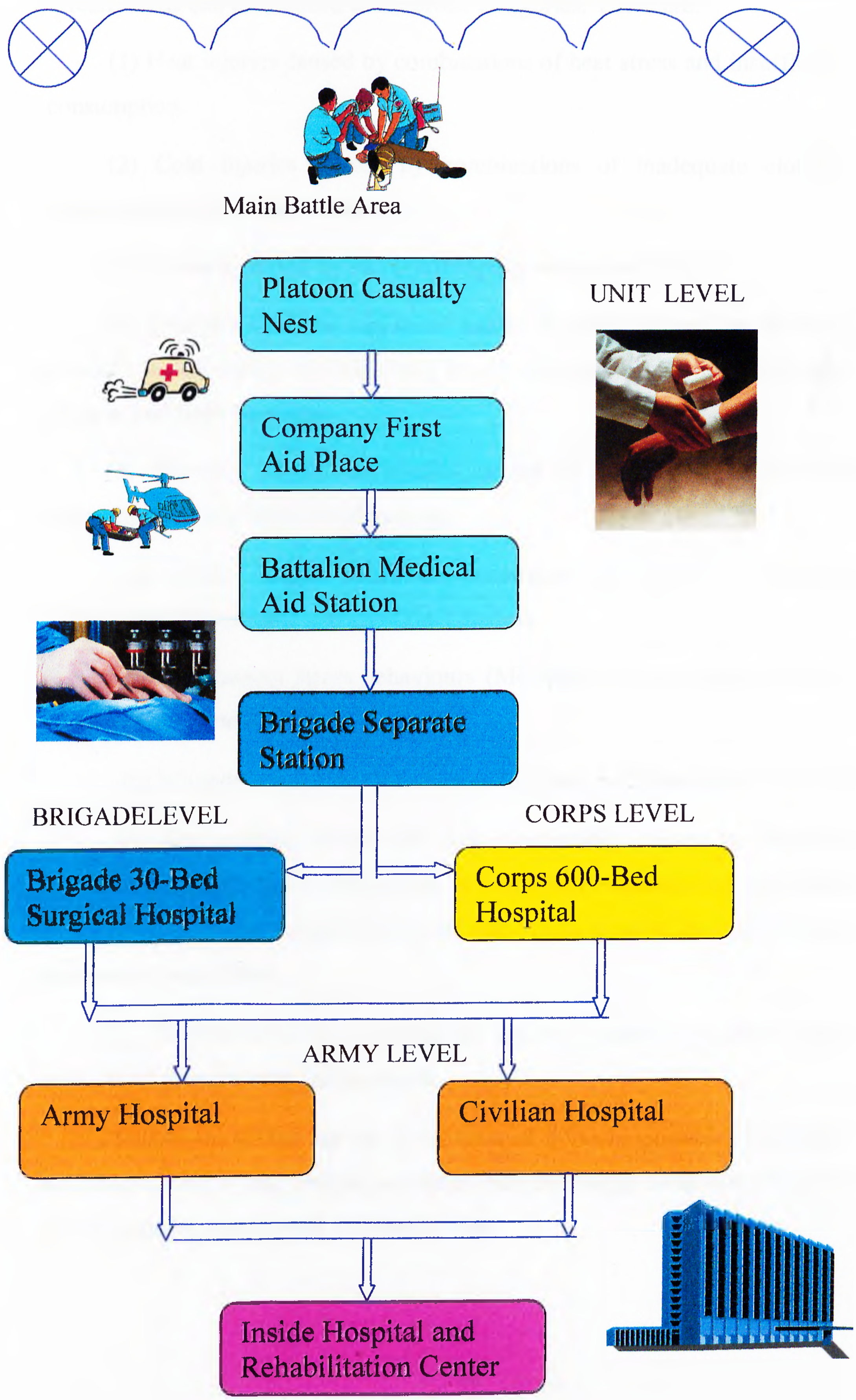
PICTURE B

MECHANIZED INFANTRY BRIGADE COMBAT ZONE



PICTURE C

TURKISH ARMY CASUALTY EVACUATION CHAIN



3. 2. Classification of Patients

The medical threat that accounts for the vast majority of combat non-effectiveness can be reduced to six broad categories. These are:

(1) Heat injuries caused by combinations of heat stress and insufficient water consumption.

(2) Cold injuries caused by combinations of inadequate clothing, low temperatures, wind, and wetness.

(3) Diseases caused by biting arthropods and animal bites.

(4) Diarrhea diseases and other enteric diseases caused by drinking non-portable water, eating contaminated foods, and not practicing good individual hygiene and field sanitation.

(5) Diseases, trauma, or injuries caused by physical or mental unfitness. Stress casualties include the following:

(a) Battle fatigue casualties encompass all forms of stress-induced performance impairment and emotional distress.

(b) Misconduct stress behaviours (MCSBs) are stress-induced behaviours which breech good discipline.

(c) Wounded-in-action (WIA) cases may also be hidden stress casualties.

(d) Any casualty whose loss was substantially caused by stress-induced performance deterioration, negligence, or impaired resistance may be considered a stress casualty. These categories may include WIAs, missing in action (MIAs), and prisoners of war (PWs).

(6). Environmental or occupational injuries caused by carbon monoxide, noise, blast overpressure, and solvents.

Patients are picked up for evacuation as soon as possible, consistent with available resources and pending missions. The following categories of precedence and the criteria used in their assignment are:

(a) **Category 1-ROUTINE** is assigned to sick, injured, or wounded personnel requiring evacuation, but whose condition is not expected to deteriorate significantly. They return to duty after treatment.

(b) **Category 2-PRIORITY** is assigned to sick, injured, or wounded personnel requiring prompt medical care. This precedence is used when the individual should be evacuated within 4 hours or his medical condition could deteriorate to such a degree that he will become an URGENT precedence, or whose requirements for special treatment are not available locally, or who will suffer unnecessary pain and disability. He is sent to Company first aid place

(c). **Category 3-URGENT** is assigned to emergency cases that should be evacuated to battalion medical aid station as soon as possible and within a maximum of 2 hours in order to save life, limb, or eyesight, to prevent complications of serious illness, or to avoid a permanent disability.

(d) **Category 4-URGENT-SURG** is assigned to patients who must receive far forward surgical intervention to save life and stabilize them for further evacuation. They are sent to the brigade separate station by helicopter. If helicopter is not available, they are send to battalion medical aid station by ambulance.

(e) **Category 5-CONVENIENCE** is assigned to patients for whom evacuation by medical vehicle is a matter of medical convenience rather than necessity. We accepted these casualties as dead.

3. 3. Factors Determining the Evacuation Policy

The following factors are used in determining the evacuation policy:

a. Nature of Tactical Operations: A major factor is the nature of the combat operations. Will they be operations of short duration and small magnitude? Will they be operations of long duration and heavy magnitude? Will NBC/DE weapons be employed? Will only conventional weapons be used? Is a static combat situation expected?

b. Number/Type of Patients: Another factor is the number and types of patients anticipated and the rate of patient returning the duty. Admission rates vary widely in different geographical areas of the world and in different types of military operations.

c. Evacuation Means: An important factor is the means (volume and type of transportation) available for evacuation of patients.

d. Availability of Replacements: Another important consideration is the capability furnishing replacements to the theater. For each patient who is evacuated from the theater to health centers a fully trained and equipped replacement must be provided. During a small-scale conflict, replacement capability would be much greater when compared to a large-scale conflict such as World War II.

e. Availability of In-Theater Resources: Limitations of all HSS resources such as insufficient numbers and types of HSS units to support the conflict zone and an insufficient amount of health service logistics and nonmedical logistics will have a definite impact on the evacuation policy. The more limitations (or shortages), the shorter will be the theater evacuation policy.

Patient evacuation can be effected immediately, procedural, and under conditions of communications silence without interrupting the continuum of care by:

(1) Preparing casualty estimates

(2) Prioritizing and task-organizing ambulance support

(3) Assigning blocks of hospital bed designations prior to the start of a mission.

Evacuation assets must have equal or greater mobility as the troops supported.

3.4. Impact of Evacuation Policy on Health Service Support Requirements

An efficient medical evacuation system:

- Minimizes mortality by rapidly and efficiently moving the sick, injured, and wounded to an MTF.
- Clears the battlefield enabling the tactical commander to continue his mission.
- Builds the morale of the soldiers by demonstrating that care is quickly available if they are wounded.
- Provides en route medical care, which is essential for optimum success.

Careful control of patient evacuation to appropriate hospitals is necessary to:

- Effect an even distribution of cases.
- Ensure adequate beds are available for current and anticipated needs.
- Route patients requiring specialized treatment to the appropriate MTF.

3.5. Evacuation Means

Depending upon the combat situation, the modes of evacuation may include walking wounded, manual and litter carries, and medical evacuation or nonmedical transportation assets. Evacuation in the battalion area normally depends on the organic ambulances assigned. Evacuation by air ambulance is dependent upon the availability of air assets, patient's medical condition, tactical situation, air superiority, and weather. Casualties can be moved from theater to the medical treatment facilities by Army aircraft, helicopters, ground ambulances or supply trucks and litters.

Litter team is the first evacuation mean in the battle area. It involves 2 soldiers and 1 team is allocated to each platoon. Litter team can move a patient with a speed of 900 meter per hour

The ambulance team or squad routinely deploys with the company trains (forward trains). It operates, however, as far forward as the tactical situation permits. The medical operations officer ensures that the ambulances are located close to the anticipated patient load. An ambulance team consists of one ambulance and two medical specialists. An ambulance can move 4 patients at the same time with a speed of 8 kilometers per hour. One or two of these teams serve in direct support of a manoeuvre company.

There are some reasons for evacuating patients by ground transportation. These are:

(1) Tactical considerations that prevent the use of aircraft for patient evacuation during certain periods

(2) Patients who cannot be evacuated by air.

(3) Weather conditions.

(4) Lack of adequate or properly located airfields.

(5) Insufficient number of aircraft available

When a casualty occurs in a tank or a Bradley infantry fighting vehicle (BIFV), the ambulance team moves as close to the armoured vehicle as possible. Assisted by the armoured crew, if possible, the casualty is extracted from the vehicle and then administered emergency medical treatment.

3.5.1. Ambulance shuttle system

The ambulance shuttle system is an effective and flexible method of employing ambulances during combat. It consists of one or more ambulance loading points, relay points, and when necessary, ambulance control points, all echeloned forward from the principal group of ambulances, the company location, or basic relay points as tactically required.

(a) Ambulance loading point: This is a point in the shuttle system where one or more ambulances are stationed ready to receive patients for evacuation.

(b) Ambulance relay point: This is a point in the shuttle system where one or more empty ambulances are stationed. They are ready to advance to a loading point or to the next relay post to replace an ambulance that has moved from it.

(c) Ambulance control point: The ambulance control point consists of a soldier (from the ambulance company or platoon) stationed at a crossroad or road junction where ambulances may take one of two or more directions to reach loading points. The soldier, knowing from which location each loaded ambulance has come, directs empty ambulances returning from the rear.

(d) Establishment of the ambulance shuttle: Once the relay points are designated, the required number of ambulances is stationed at each point.

(e) The ambulance shuttle system is applied after Battalion level, between battalion and Brigade level, between brigade level and corps level etc.

3. 6. The Existing Medical Treatment System

Health service support in the brigade is provided by a modular support system that standardizes all medical sub elements. The HSS modular design enables the medical resources manager to rapidly tailor, augment, reinforce, or reconstitute the HSS units as needed. This system is designed to acquire, receive, and triage patients, and to provide emergency medical treatment (EMT) and advanced trauma management (ATM).

The modular medical support system is built around four modules. These modules are oriented to casualty collection, treatment, and RTD or evacuation.

(1) Combat medic. The combat medic module consists of one combat medical specialist and his prescribed load of medical supplies and equipment. Combat medics are organic to the medical platoons or sections of combat and combat support (CS) battalions and are attached to the companies of the battalions.

Health service support originates in the forward areas with the combat lifesaver and combat medic (aidman) supporting each combat team. This is called Echelon 1 or Level 1 care, which is provided by an individual (self-aid, buddy aid, combat lifesaver, or combat medic) or by medical personnel in a treatment squad.

This initial care consists of those lifesaving steps that do not require the knowledge and skill of a physician. The following three different skill levels of personnel provide the care required in the forward area.

(a) Self-aid/buddy aid. Each individual soldier is trained to be proficient in a variety of specific first-aid procedures. These procedures include aid for chemical casualties with particular emphasis on lifesaving tasks. This training enables the soldier or a buddy to apply immediate care to alleviate a life-threatening situation.

(b) Combat lifesaver. The combat lifesaver is a member of a non-medical unit selected by the unit commander for additional training beyond basic first-aid procedures.

(c) Combat medic (aidman). This is the first individual in the HSS chain who makes medically substantiated decisions based on medical MOS-specific training. The combat medic is trained to emergency medical technician (EMT) level. The combat medic is assigned to the medical platoon or section of the HHC, the HSC, or the troop of the appropriate combat or CS battalion.

(2) Ambulance squad. An ambulance squad is comprised of four medical specialists and two ambulances. This squad provides patient evacuation throughout the brigade and provides en route care. Ambulance squads are organic to the medical platoons or sections in manoeuvre battalions, and to the medical companies of the brigade support command. Medical company ambulance squads are located in the brigade support area (BSA). The medical platoon's ambulance squads are further attached to the companies of the manoeuvre battalions.

(3) Treatment squad. This squad consists of a primary care physician, a physician assistant (PA), and six medical specialists. The squad is trained and equipped to provide ATM to the battlefield casualty.

(4) Surgical squad/detachment. This module is comprised of two surgeons, two nurse anesthetists, two operating room specialists, one medical/surgical nurse, and two practical nurses. It is organized to provide early resuscitative surgery for seriously wounded or injured patients, to save life, and to preserve physical function. Early surgery is performed whenever a likely delay in the evacuation of a patient threatens life or the quality of recovery. They normally are employed in the BSA during brigade task force operations.

There are 5 levels in the Turkish Land Army HSS system. These are unit level (level or echelon 1), which involves platoon casualty nest, company first aid place and battalion medical aid station, Brigade Level which involves brigade separate station and 30-bed surgical hospital, Corps level which involves 600-bed stationary hospital, Army Level which involves army hospital and Inside level which involves the regional military hospitals and rehabilitation center (See Picture B and C for the entire picture).

3. 6. 1. Level 1 (Unit Level)

a. Platoon Casualty Nest: The mission of platoon casualty nest is to satisfy first aid to the casualties, to stabilize them for further evacuation and to prioritize at the conflict area. There are three medical persons in the platoon casualty nest, 1 aidman (combat lifesaver) and 1 litter team involving two persons. It is approximately 50 to 150 meters from the main battle area.

b. Company First Aid Place: The mission of company first aid place is to make more serious treatment than combat lifesaver and to make patients ready for further evacuation to battalion medical aid station. There is the Area Damage Control (ADC) team, which involves 1 medical specialist, 3 aidmen (1 for each platoon), 1 jeep ambulance and 4 litter teams (1 for each platoon and 1 for him). NCO of company is responsible for the ADC. The ADC team is responsible for directing and assisting with the transportation of casualties to the company's Casualty Collection Point (CCP). The company first aid place is approximately

450 meters far away from the main battle area. The specialist again prioritize the patients and those patients not requiring a higher level of care are returned to duty, the dead are sent to dead collection point and the others are sent to battalion medical aid station.

c. Battalion Medical Aid Station: This is the first place that consists of a doctor. Its mission is to receive the incoming patients, to clean those who are affected from the NBC (Nuclear, Biological and Chemical) weapons, to triage and to stabilize them by making the first medical treatment. If the patient can be treated here he is sent to the duty, if can't be treated sent to the brigade separate station. There is no ward (bedroom) providing pre-operative and post-operative acute nursing care. The patients should be sent to brigade separate station in 1 to 6 hours. There is 1 doctor, 4 ambulances (1 for each company and 1 for himself). It is approximately 3000 meters or 5000 meters far from the main battle area.

The new system's procedure is different from the existing system's procedure. In the new system the patients are prioritized and can be directly send to either one of the brigade separate station, brigade 30-bed hospital and 600-bed stationary hospital or civilian hospital.

3. 6. 2. Level 2 (Brigade Level)

a. Brigade Separate Station: The mission of the brigade separate station is to provide early emergency hospitalization for patients who are unable to tolerate and survive movement over long distances and who require resuscitative surgical care and to provide medical treatment for sick patients and to stabilize them for further evacuation to either combat zone or one of the higher level hospitals. It will be deployed as close as tactically feasible, preferably the Brigade forward area. It is approximately 7 to 10 kilometers far from the main battle area.

This unit provides:

* Receive, triage, and stabilize incoming patients.

* Clean the patients who are affected from the NBC (Nuclear, Biological and Chemical) weapons

* Initial resuscitative surgery and medical treatment for patients requiring stabilization prior to further evacuation.

* Three wards (12 beds providing medical care, 9 beds providing neuropsychiatric care and 9 beds providing post-operative care) providing post-operative acute nursing care

* Surgical capability based on two operating room tables for general, thoracic, and orthopedic surgical operations. This means there are two surgeries.

* There is one doctor for medical treatment and two therapists for the patients under shock and need therapy.

* The brigade separate station is 100 percent mobile.

* A patient can be held in the ward maximum for 3 days

If the patient can be treated, he is sent to duty. If he can't be treated and needs medical treatment, he is sent to the army or civilian hospital. If patient needs physiological treatment, he is sent to the 600-bed hospital. If the patient needs surgical operation, he is sent to either 30-bed hospital or 600-bed hospital (If 30-bed hospital is full).

b. Brigade 30-Bed Surgical Hospital: The mission of the brigade 30-bed hospital is to provide hospitalization for patients who require surgical care to make final treatment for further evacuation to combat zone or to stabilize them for further evacuation to one of the higher level hospitals. It will be deployed as far forward as tactically feasible, preferably the brigade rear area. It is located approximately 8 to 11 kilometers from the main battle area and 1 to 1.5 kilometers from the brigade separate station.

This unit provides:

* Receive, triage, and stabilize incoming patients.

* Initial resuscitative surgery for patients requiring stabilization prior to further surgery or recovery surgery.

* Two wards (15 beds for emergency surgery treatment room, 15 beds for recovery (normal) surgery treatment room.) providing postoperative acute nursing care.

* Surgical capability based on two operating room tables for general, thoracic, and orthopedic surgical operations. One of the surgery desks is for emergency surgery and the other is for the normal surgery. This means there are two surgeries.

* The brigade 30-bed hospital is 100 percent mobile.

* A patient can be held in the ward maximum for 3 days.

If the patient is treated, he is sent to duty. If the patient isn't treated and needs medical treatment, he is sent to the army or civilian hospital. If the patient needs surgical operation (or if 30-bed hospital can't do a successful operation), he is sent to the 600-bed hospital.

3. 6. 3. Level 3 (Corps Level)

600-Bed Hospital: Main mission is to provide surgical, physiological and general treatment to corps battle area. It is located 15 to 30 kilometers from the main battle area. A patient can be held maximum for 7 days. There are 8 surgical desks.

If the patient is treated, he is sent to duty, otherwise he is sent to either the army hospital or the civilian hospital. The majority of patients within this facility are in the rehabilitative category.

3. 6. 4. Level 4 (Army Level)

a. Army Hospital: Main mission is to provide surgical, physiological and general treatment to army battle area. It is located 55 to 100 kilometers from the main battle area. A patient can be held maximum for 10 days.

If the patient is treated, he is sent to duty, otherwise he is sent to regional stationary hospital or rehabilitation center. The majority of patients within this facility are in the rehabilitative category. As patients are evacuated to the rear, treatment is more definitive. For the majority of patients, definitive treatment constitutes all that is needed for them to return to fill and useful duty.

b. Civilian Hospital: Main mission is to provide surgical, physiological and general treatment to corps or army battle area in addition to its own responsibilities. It is located near a corps headquarters or an army headquarters. A patient can be held for 7 to 10 days.

If the patient is treated, he is sent to duty, otherwise he is sent to regional stationary hospital or rehabilitation center.

However Civilian casualties may be a significant problem in populated areas, and Military Health Support Units may be required to assist in treating civilian patients when civil medicine cannot handle the problem. The majority of patients within this facility are in the rehabilitative category.

3. 6. 5. Level 5 (Rehabilitation Center)

Rehabilitation Center: Main mission is to provide definitive treatment to the patients. It is located inside the country. A patient is held until he is recovered without looking at any time limitations. The following two care methods are conducted at this level.

a. Convalescent Care

During this phase in a patient's recovery, medical supervision is still needed, but the patient's condition does not require the frequent or close monitoring characteristic of the acute stage. Convalescent care occurs in several types of settings. This care can be given on an outpatient basis, in a holding unit, or in a hospital. This phase involves clinical judgment to determine when the patient has:

(1) Recovered from an injury or disease.

(2) Achieved a state of physical and mental function commensurate with the job to which the soldier will be subsequently assigned.

b. Rehabilitative Care

Rehabilitation is part of the total medical care provided to patients in the definitive and convalescent phases of care. Preventing or minimizing loss of physical or psychological function for patients capable of being RTD are the primary goals. For patients requiring evacuation, treatment is aimed toward starting basic rehabilitation procedures that can be continued throughout the evacuation process.

Physical and occupational therapy are the rehabilitation assets in a TO.

3.7. The Proposed New System

The first purpose of proposed system is to decrease the time in queues, to decrease the number of patient waiting in queues, to increase speed of flow of patients in army health-care system. Its second purpose is to decrease number of dead and to increase number of patient returning to duty.

For this purpose main change is done at battalion level. At this level, if the patient can not be recovered, an important initiative will be given to doctor to send the patient to one of the brigade separate station, brigade 30-bed surgical hospital, corps 600-bed hospital and civilian hospital. In the existing system the patient can be sent to only brigade separate station. Until battalion the proposed system is the same with the existing system.

If the patient can't be recovered at brigade separate station, she/he can be sent to one of 30-bed surgical hospital, corps 600-bed hospital, and civilian hospital or army stationary hospital. If the patient can't be recovered at 30-bed surgical hospital, she/he can be sent to one of 30-bed surgical hospital, corps 600-bed hospital, and civilian hospital or army stationary hospital.

If the patient can't be recovered at 600-bed Hospital, she/he can be sent to either civilian hospital or army stationary hospital. If the patient can't be recovered at civilian hospital, she/he can be sent to rehabilitation center. If the patient can't be recovered at army hospital, she/he can be sent to rehabilitation center. The properties of these health units and centers (number of doctors, number of beds, etc.) as are in the existing system.

To observe the behaviour of the proposed system, see the flow chart of the proposed system:

PROPOSED SYSTEM, GENERAL FLOWCHART OF CASUALTY EVACUATION OF BRIGADE IN DEFENCE OPERATION

↓

A CASUALTY OCCURS

↓

CASUALTY HIMSELF, OR BUDDY, OR AIDMAN MAKES THE INITIAL TREATMENT

↓

IF HE CAN BE TREATED HE IS SENT TO DUTY
IF CAN'T BE TREATED HE IS MOVED TO PLATOON CASUALTY NEST BY LITTER TEAM OR ON FOOT

↓

PLATOON CASUALTY NEST

IF HE CAN BE TREATED HE IS SENT TO HIS DUTY,

CATEGORY 2: IF PATIENT IS PRIORITIZED AS ROUTINE INJURY OR AS PRIORITY SEND TO THE COMPANY FIRST AID PLACE

CATEGORY 3: IF PATIENT IS ACUTE , BUT HELICOPTER ISN'T AVAILABLE SENT TO BATTALION MEDICAL AID STATION BY AMBULANCE

CATEGORY 4: IF HE IS ACUTE AND HELICOPTER IS AVAILABLE SENT TO BRIGADE SEPARATE STATION BY HELICOPTER

CATEGORY 4

CATEGORY 3

CATEGORY 2

BRIGADE SEPARATE STATION:

EXAMINE THE PATIENT AND TRIAGE;

CATEGORY A: PATIENT'S ILLNESS NEEDS SOME MEDICAL TREATMENT, APPLY TREATMENT, IFCAN'T BE TREATED HERE MOVE TO HIGHER HEALTH CENTER LEVELS

CATEGORY B:TREAT PATIENTS WHO NEED THERAPY, IF CAN BE TREATED HERE SEND TO DUTY OTHERWISE MOVE TO HIGHER HEALTH CENTER LEVELS

CATEGORY C: PATIENTS WHO NEED SURGICAL OPERATION, STABILIZE THE PATIENT IF CAN'T, MOVE TO HIGHER HEALTH CENTER LEVELS

BATTALION MEDICAL AID STATION :

EXAMINE THE PATIENT, AND APPLY FIRST TREATMENT. IF CAN BE TREATED SENT TO DUTY, OTHERWISE MOVE TO HIGHER HEALTH CENTER LEVELS

COMPANY FIRST AID PLACE:

EXAMINE THE PATIENT, AND APPLY FIRST TREATMENT. IF CAN BE TREATED HERE SENT TO DUTY, OTHERWISE MOVE HIM TO BATTALION FIRST AID STATION

30-BED MOBILE SURGICAL HOSPITAL:

APPLY SURGICAL OPERATION , IF OPERATION IS SUCCESSFUL SEND HIM TO HIGHER HEALTH CENTER LEVELS IF NOT SEND TO CORPS 600-BED HOSPITAL

CORPS 600-BED HOSPITAL:

APPLY SURGICAL OPERATION OR PHYSIOLOGICAL AND GENERAL TREATMENT THEN SEND HIM TO HIGHER LEVEL HEALTH CENTERS

CIVILIAN STATIONARY HOSPITAL;

MAKE THE GENERAL TREATMENT AND SEND HIM TO REGIONAL STATIONARY HOSPITAL AND REHABILITATION CENTER

ARMY STATIONARY HOSPITAL;

MAKE THE GENERAL TREATMENT AND SEND HIM TO REGIONAL STATIONARY HOSPITAL AND REHABILITATION CENTER

AND REHABILITATION CENTER
MAKE FINAL TREATMENT AND SEND BACK TO HIS DUTY

3.8. Medical Evacuation Support of Defensive Operations

Support is generally more difficult to provide in defensive operations. The patient load reflects lower casualty rates, but forward area patient acquisition is complicated by enemy actions and the maneuver of combat forces. Medical personnel are permitted much less time to reach the patient, complete vital EMT, and remove him from the battle site. Increased casualties among exposed medical personnel further reduce the medical treatment and evacuation capabilities. Heaviest patient workloads, including those produced by enemy artillery and NBC weapons may be expected during the preparation or initial phase of the enemy attack and in the counterattack phase. The enemy attack may disrupt ground and air routes and delay evacuation of patients to and from treatment elements. The depth and dispersion of the defence create significant time and distance problems for evacuation assets. Combat elements may be forced to withdraw while carrying their remaining patients to the rear. The enemy exercises the initiative early in the operation that may preclude accurate prediction of initial areas of casualty density. This makes the effective integration of air assets into the evacuation plan essential.

3. 9. Medical Evacuation of Enemy Prisoners of War

Sick, injured, and wounded EPWs are treated and evacuated in regular channels when possible. They must be physically segregated from Turkish and allied patients. Guards for these prisoners are provided in accordance with the division or corps military police and are from other than medical resources. Medical evacuation of enemy prisoners of war is not involved in our simulation model.

CHAPTER 4

SIMULATION MODEL OF CASUALTY EVACUATION OF BRIGADE IN DEFENCE OPERATION

4. 1. General

Simulation has many advantages over more traditional approaches to process improvement in casualty evacuation. It provides an objective way to test different alternative processes. Simulation also delivers a quantified difference between the different alternatives. Simulation is not emotional and has no territorial urges. Simulation shows how a change in one area of a medical treatment facility will affect operations in other areas. Simulation is useful in verifying the architectural design for a new construction project. Plans can be tested and modified prior to final approval (Banks, 1998).

In this study, simulation is used to analyse the behaviour of the Mechanized Infantry Brigade's casualty evacuation in defence operation. The simulation was conducted using ARENA 3.0 Simulation Software Package for a period of 10 days (14400 minute). This period is called as "Short-term Period" in operation planning. Developing weapon, communication and transportation technologies force the war to be ended in a few days. Huge economical damage of war forces the countries not to make war. But if it is inevitable they want to finish the war in a few days. For this reason we take period as 10-day period.

We have chosen ARENA that has ability to describe environments as stations and has ability to define a sequence for moving entities through the system. It enables the modelling of systems including transporters, it includes menu-driven point-and-click procedures for constructing the SIMAN V model and experiment, animation using Cinema, input processor that assists in fitting distributions to data, and the output processor that can be used to obtain confidence intervals, histograms, correlograms and so on, it is portable to all types of computers (Banks, Carson and Nelson, 1995).

The system under consideration is terminating system. Because there is a natural event E that specifies the length of each run. The goal of this simulation is to determine the final casualty numbers according to their types, procedure and system times of medical treatment facilities and medical persons when the battle ends. In this case E = {either the blue force or the red force has "won" the battle} (Law and Kelton, 1991). We create totally 17 alternative simulation models for this study. We perform two simulation experiments for the comparison of the existing system and the new proposed system. We run the model of each alternative system for 10 replications in approximately 7 minutes. We create 5 alternative systems for ranking and selection procedure "the best of k systems" and we run the model of each alternative system for 20 replications for first stage and for 30 replications for second stage in approximately 3 hours. We create 6 scenarios to see the behaviour of the system under increased arrival rate, and 6 scenarios to solve the problems that are observed after analyzing the first 6 scenarios and we run the model of each scenario for 10 replications in about 2.5 hours. The simulation model's size is 5,84 MB and in SIMAN it is 2200-line code.

4. 2. Conceptual Model of the System

4. 2. 1. Events

In this model the events are transportation of patients to medical units, registering, examining, triage, sending to higher level medical units or sending to duty and making the final treatment. In addition, there are some laboratory testing in some medical units.

4. 2. 2. Facilities

The facilities are buddy, aidman in platoon casualty nest, specialist in company first aid place, registry personnel, NBC (Nuclear Biological Chemical) cleaning specialist and doctor in battalion medical aid station, registry personnel, NBC (Nuclear Biological Chemical) cleaning specialist, surgery, physiological therapist and doctor in brigade separate station, registry personnel, surgery, laboratory expert and X-ray operator in brigade 30-bed surgical hospital, doctor in 600-bed corps hospital, doctor in army hospital, doctor in civilian hospital, doctor in rehabilitation center, wards, litter team, ambulance and helicopter.

4. 2. 3. Exogeneous (Input) Variables

Exogenous variables are number of litter teams, number of ambulances and helicopters, number of aidman, number of specialist, number of doctors, number of surgeries, number of therapists, number of laboratory expert, number of NBC cleaning specialist, number of registry personnel, transportation time, service time of doctors and other medic personnel, service time of surgeries, service time of therapist, service time of laboratory expert, service time of registry personnel, service time of NBC cleaning specialist and time in wards.

4. 2. 4. Endegenous (Output) Variables

Endogenous variables are number of patients, examination time of each patient, doctor utilization and idle time processing time of laboratory registry time of each patient.

4. 2. 4. 1. State Variables

State of doctor, state of other medic personnel (busy or idle), state of laboratory, state of NBC Cleaning center, state of litter team, state of ambulance, state of helicopter, state of X-ray operator, state of registry personnel, state of ward, number of patient waiting for treatment and number of patient waiting for bed are the state variables of the system.

4. 2. 4. 2. Performance Measures

Utilization of doctors and the other medic personnel, utilization of surgery, utilization of therapist, utilization of registry, utilization of laboratory expert, utilization of X-ray operator, utilization of NBC cleaning operator, utilization of litter team, utilization of ambulances and utilization of beds.

(1) Treatment Times:

Time in Platoon Casualty Nest: This time begins when the soldier is injured and ends when the soldier leaves the platoon casualty nest.

Time in Company First Aid Place: This time begins when the casualty arrives at the company first aid place and ends when the soldier leaves the company first aid place.

Time in Battalion Medical Aid Station: This time begins when the casualty arrives at battalion medical aid station and ends when the soldier leaves the battalion medical aid station.

Time in Brigade Separate Station: This time begins when the patient arrives at the brigade separate station and ends when the soldier leaves the brigade separate station.

* **Time in Brigade Separate Medical Treatment Section:** This time begins when the patient arrives at the brigade separate medical treatment section and ends when the soldier leaves this section's ward.

* **Time in Brigade Separate Physiological Therapy Section:** This time begins when the patient arrives at the brigade separate physiological therapy section and ends when the soldier leaves this section's ward.

* **Time in Brigade Separate Surgery Section:** This time begins when the patient arrives at the brigade separate surgery section and ends when the soldier leaves this section's ward.

* **Time in Brigade Separate Medical Treatment Section Bed:** This time begins when the patient arrives at the bed queue and ends when he leaves the ward.

* **Time in Brigade Separate Physiological Therapy Section Bed:** This time begins when the patient arrives at the bed queue and ends when he leaves the ward.

* **Time in Brigade Separate Surgery Section Bed:** This time begins when the patient arrives at the bed queue and ends when he leaves the ward.

Time in Brigade 30-Bed Hospital Emergency Surgery Section: This time begins when the patient arrives at the brigade 30-bed surgical hospital emergency surgery section and ends when the soldier leaves this section's ward.

* **Time in Brigade 30-Bed Hospital Emergency Surgery Section Bed:** This time begins when the patient arrives at the bed queue and ends when he leaves the ward.

Time in 30-Bed Hospital Normal Surgery Section: This time begins when the patient arrives at the brigade 30-bed surgical hospital normal surgery section and ends when the soldier leaves this section's ward.

* **Time in 30-Bed Hospital Normal Surgery Section Bed:** This time begins when the patient arrives at the bed queue and ends when he leaves the ward.

Time in 600-Bed Hospital: This time begins when the patient arrives at the 600-bed hospital and ends when the soldier leaves this hospital.

Time in Army Hospital: This time begins when the patient arrives at the Army Hospital and ends when the soldier leaves this hospital.

Time in Civilian Hospital: This time begins when the patient arrives at the Civilian Hospital and ends when the soldier leaves this hospital.

Time in Rehabilitation Center: This time begins when the patient arrives at the Rehabilitation center and ends when the soldier leaves this hospital.

(2) Time in System

Time in System of Platoon Casualty Nest: This time begins when the soldier is injured and ends when the soldier leaves the platoon casualty nest.

Time in System of Company First Aid Place: This time begins when the soldier is injured and ends when the soldier leaves the company first aid place.

Time in System of Battalion Medical Aid Station: This time begins when the soldier is injured and ends when the soldier leaves the battalion medical aid station.

Time in System of Brigade Separate Medical Treatment Section: This time begins when the soldier is injured and ends when the soldier leaves this section's ward.

Time in System of Brigade Separate Physiological Therapy Section: This time begins when the soldier is injured and ends when the soldier leaves this section's ward.

Time in System of Brigade Separate Surgery Section: This time begins when the soldier is injured and ends when the soldier leaves this section's ward.

Time in System of Brigade 30-Bed Hospital: This time begins when the soldier is injured and ends when the soldier leaves this hospital (Here it takes longest time of Emergency surgery section and normal surgery section).

Time in System of 600-Bed Hospital: This time begins when the soldier is injured and ends when the soldier leaves this hospital.

Time in System of Army Hospital: This time begins when the soldier is injured and ends when the soldier leaves this hospital.

Time in System of Civilian Hospital: This time begins when the soldier is injured and ends when the soldier leaves this hospital.

Time in System of Rehabilitation Center: This time begins when the soldier is injured and ends when the soldier leaves this hospital.

(3) Time in Queue

Time in queue statistics are: Platoon aidman queue, company specialist queue, battalion doctor queue, queue for doctor of brigade separate medical treatment section, queue for therapist of brigade separate psychotherapy section, queue for surgeon of brigade separate surgery section, queue for bed of brigade separate medical treatment section, queue for bed of brigade separate psychotherapy section, queue for bed of brigade separate surgery section, queue for surgeon of 3O-bed hospital emergency surgery unit, queue for surgeon of 30-bed hospital normal surgery unit, queue for bed of 3O-bed hospital emergency surgery section and queue for bed of 30-bed hospital normal surgery section.

(4) Number of Patients

The related statistics are: Number of patients entering to platoon, returning to duty, dying and going to higher level medical treatment facilities; number of patients entering to company, returning to duty, dying and going to higher level medical treatment facilities; number of patients entering to battalion, returning to duty, dying and going to higher level medical treatment facilities; number of patients entering to brigade separate section, returning to duty, dying and going to higher level medical treatment facilities; number of patients entering to brigade separate medical treatment section, returning to duty, dying and going to higher level medical treatment facilities; number of patients entering to brigade separate physiological therapy section, returning to duty, dying and going to higher level medical treatment facilities; number of patients entering to brigade separate surgery section, returning to duty, dying and going to higher level medical treatment facilities; number of patients entering to 30-bed hospital emergency surgery section, returning to duty, dying and going to higher level medical treatment facilities; number of patients entering to 30-bed hospital normal surgery section, returning to duty, dying and going to higher level medical treatment facilities; number of patients entering to 30-bed hospital, returning to duty, dying and going to higher level medical treatment facilities; number of patients entering to 600-bed hospital, returning to duty, dying and going to higher level medical treatment facilities; number of patients entering to army hospital, returning to duty, dying and going to higher level medical treatment facilities; number of patients entering to civilian hospital, returning to duty, dying and going to higher level medical treatment facilities; number of patients entering to rehabilitation center, returning to duty, dying and going to higher level medical treatment facilities;

number of patients entering in system, returning to duty, dying and staying in system to be treated.

(5) Number of Patients in Queue

These are: Number of patients in platoon aidman queue, number of patients in queue of company's specialist, number of patients in queue of Battalion doctor, number of patients in queue for doctor of brigade separate medical treatment section, number of patients in queue for therapist of brigade separate physiological treatment section, number of patients in queue for surgeon of brigade separate surgery section, number of patients in queue for surgeon of 30-bed hospital emergency surgery section, number of patients in queue for surgeon of 30-bed hospital normal surgery section, number of patients in queue for bed of brigade separate medical treatment section, number of patients in queue for bed of brigade separate physiological therapy section, number of patients in queue for bed of brigade separate surgery section, number of patients in queue for bed of 30-bed hospital emergency surgery section and number of patients in queue for bed of 30-bed hospital normal surgery section.

(6) Utilization of Simulation Model of Casualty Evacuation of Brigade

Utilization of platoon aidman, utilization of company's specialist, utilization of battalion doctor, utilization of doctor of brigade separate medical treatment section, utilization of therapist of brigade separate physiological treatment section, utilization of surgeon of brigade separate surgery section, utilization of surgeon of 30-bed hospital emergency surgery section, utilization of surgeon of 30-bed hospital normal surgery section, utilization of bed of brigade separate medical treatment section, utilization of bed of brigade separate physiological therapy section, utilization of bed of brigade separate surgery section, utilization of bed of 30-bed hospital emergency surgery section and utilization of bed of 30-bed hospital normal surgery section.

4.2.5. Assumptions of Simulation Model of Casualty Evacuation of Brigade

* In this study our main goal is to model Brigade. But to show flow of patient through all the system from platoon to rehabilitation center we made simulation model of all the system. But we assume that there is only one brigade in the system. For this reason the results belonging to 600-bed hospital, army hospital, civilian hospital and rehabilitation center don't represent the true values.

* We assume that for each patient who is evacuated from the theater to health centers a fully trained and equipped replacement is provided.

* The soldier who returned to duty can be injured again and go to health centers and return to duty and can be wounded again and so on.

* We designed the battalion organization as Battalion Task Force. For this purpose we assigned support troops to each battalion by equal power.

* We assume that total number of bed of Brigade Separate Station is 30.

* We do not include some of the performance measures in tables, and we don't use them for analyzing the simulation model, because they have the same values with the other units or they are not important for main goal of this study. For example platoons of second company, platoons of other companies, companies of second and third battalions, performance measures related to transportation means. We did not include second battalion in some tables either, because its values are close to values of first battalions. The reason for that is, both of them are on the main battle area.

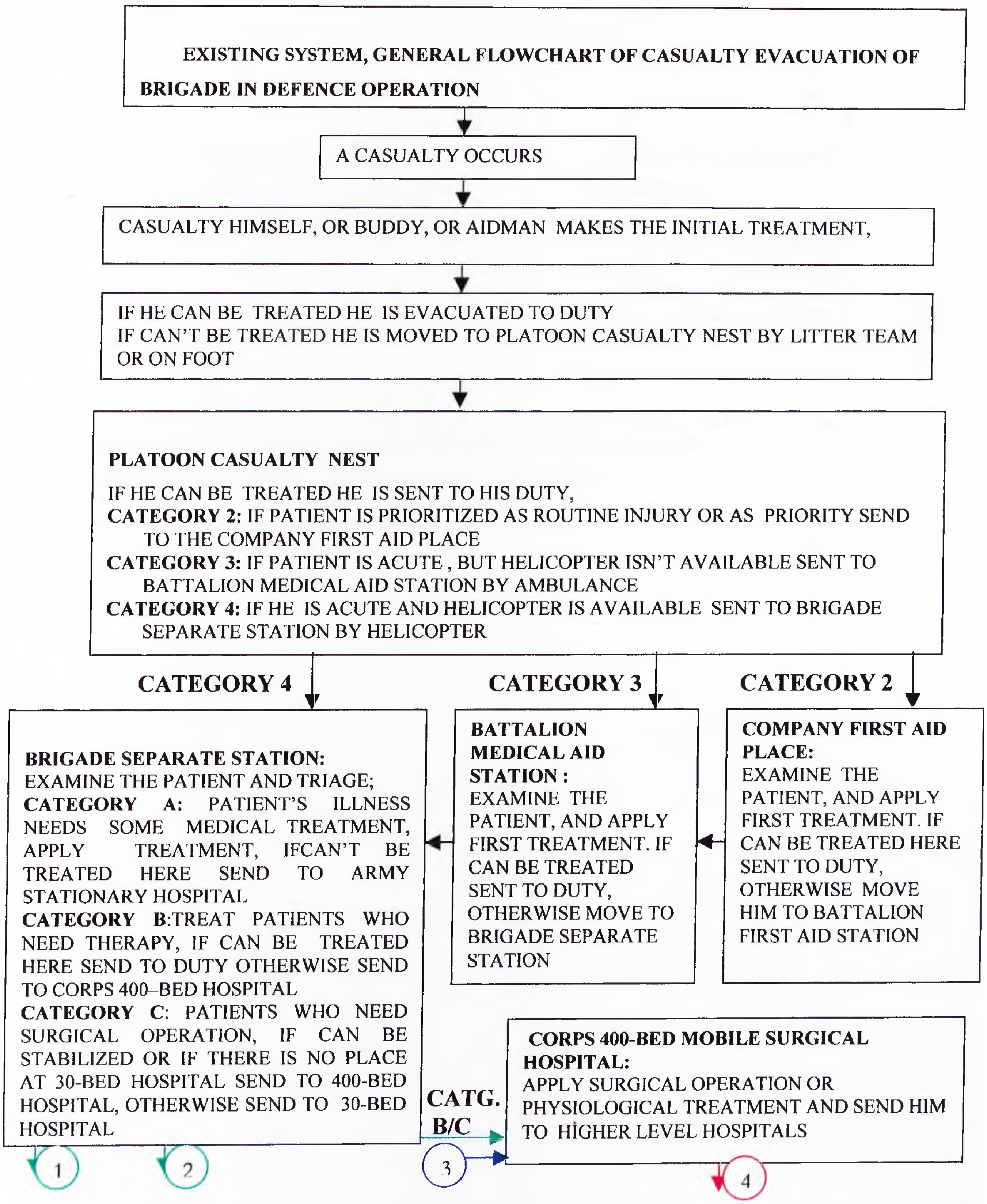
* We determine the brigade separate station's wards' bed capacity and 30-bed hospital's wards' bed capacity by using the patient categories' rates.

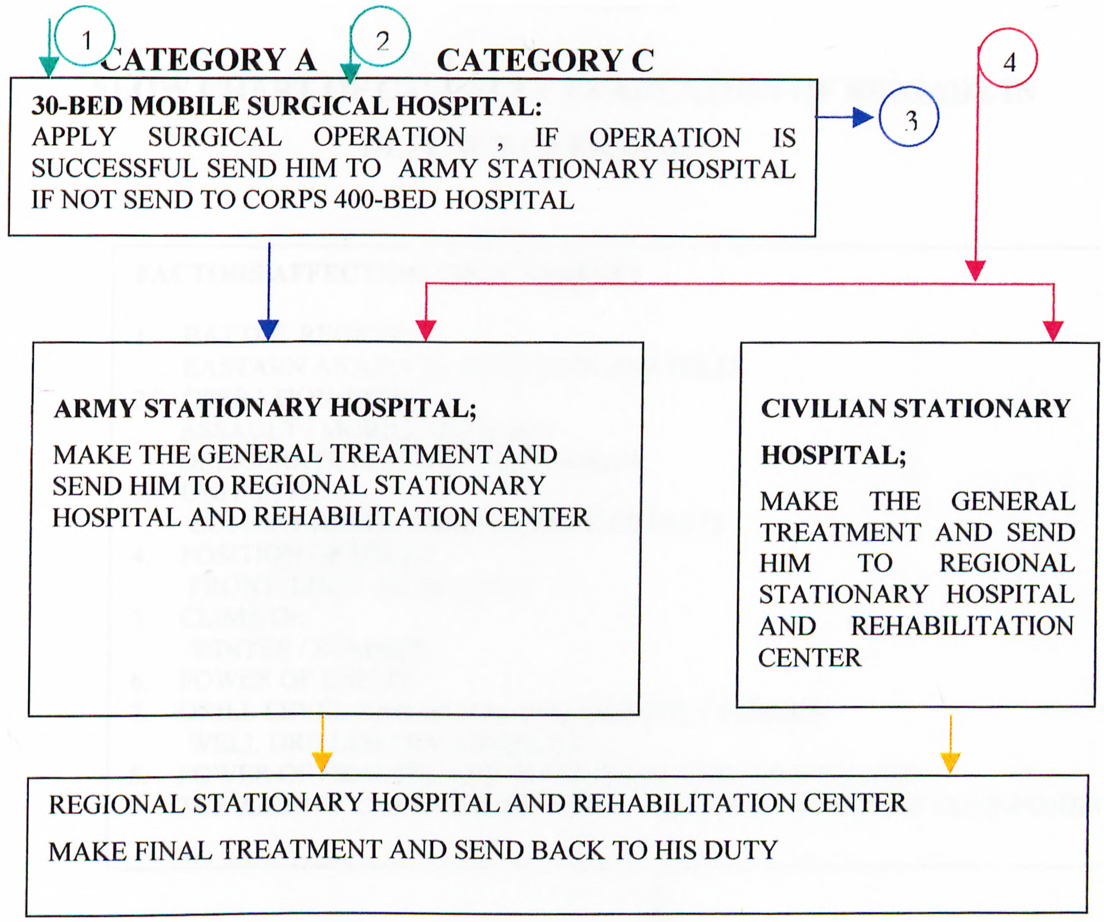
4. 2. 6. Limitations

Because of army's security rules we can not explain exact organization of brigade, and hence we can not use exact data values. But we try to use estimated data as close as possible to the real ones.

4. 3. Flow Chart of the Model

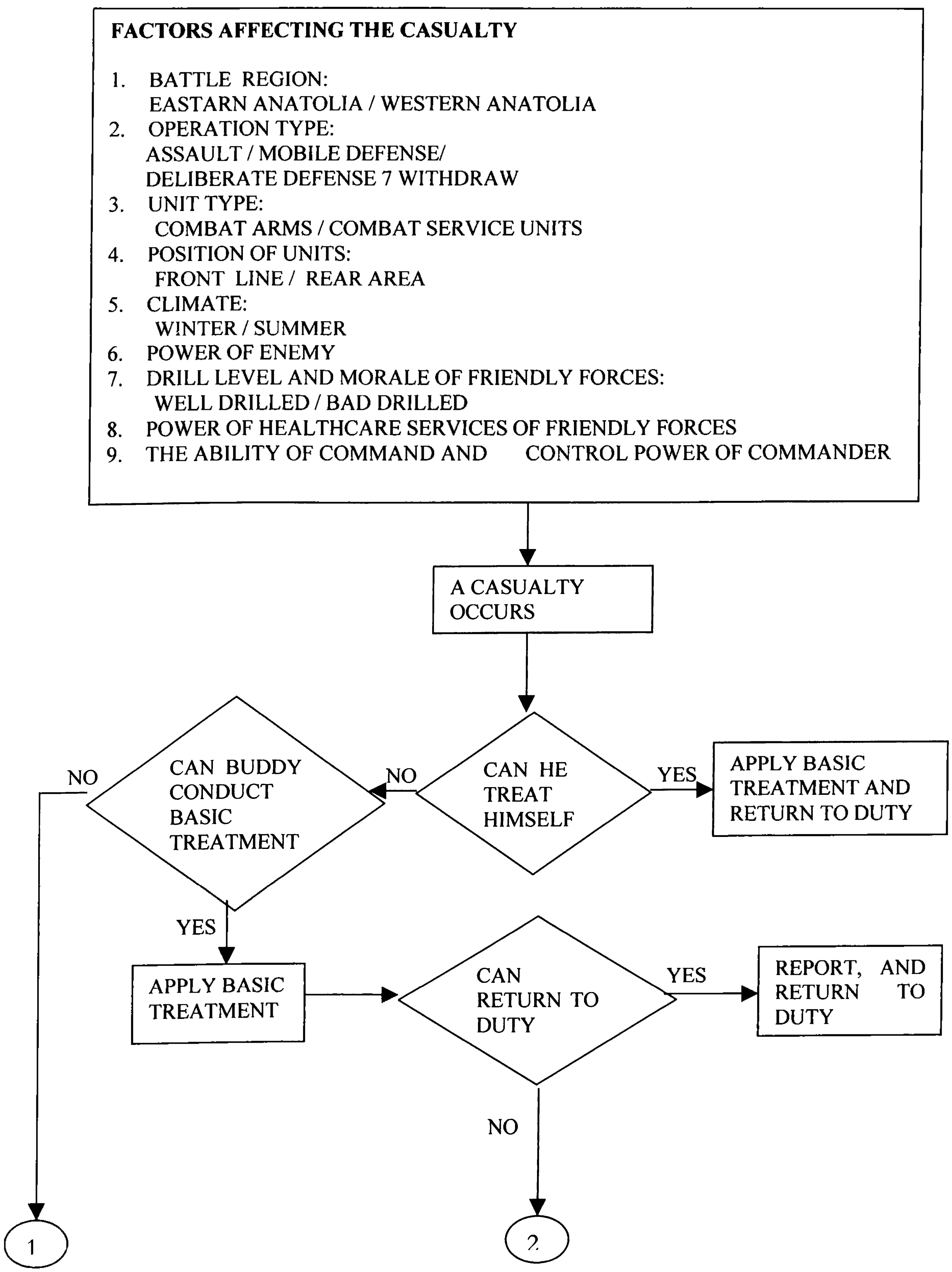
To observe behaviour of the existing system, see general flow chart of existing system and detailed flow chart of existing system. General flow chart:

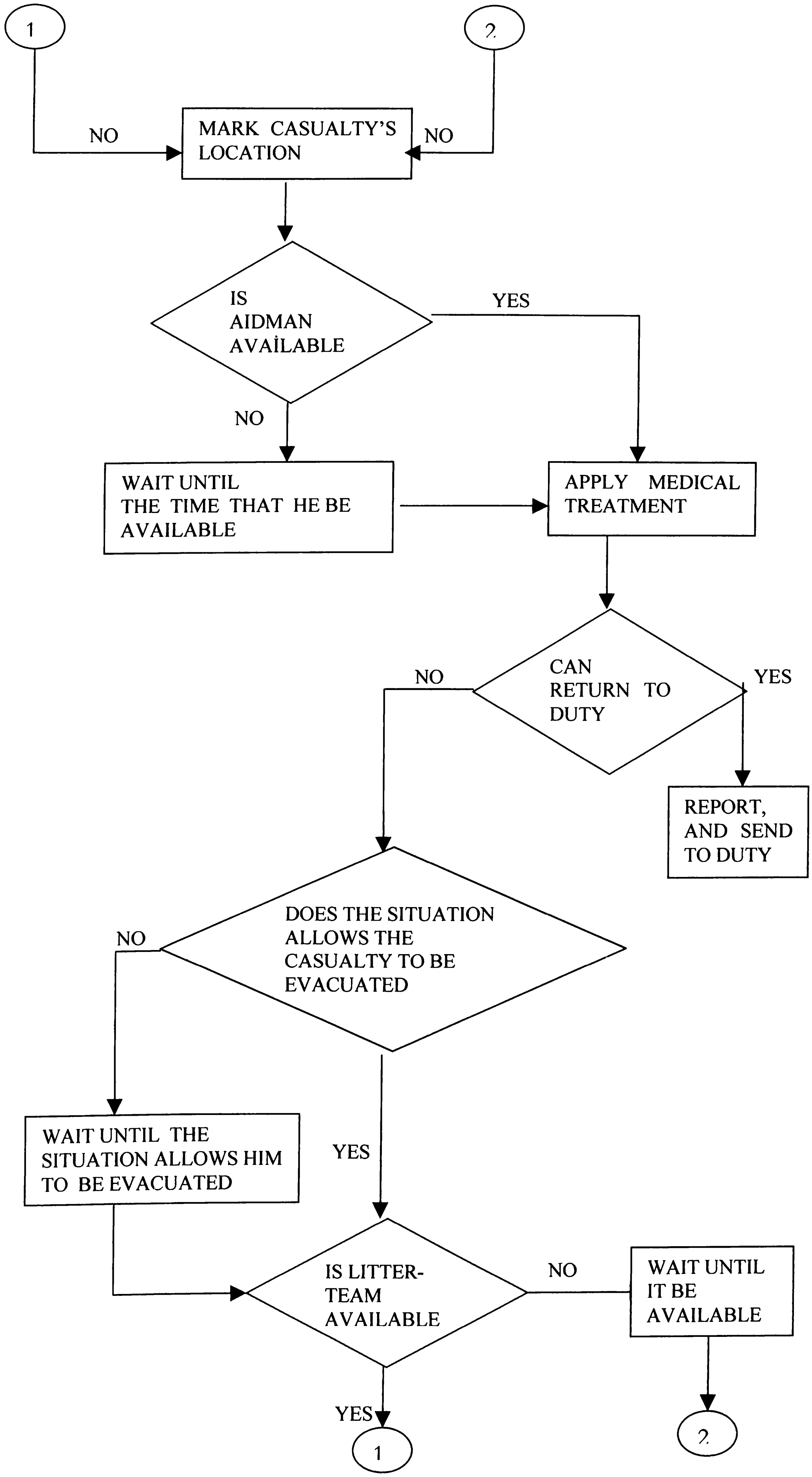


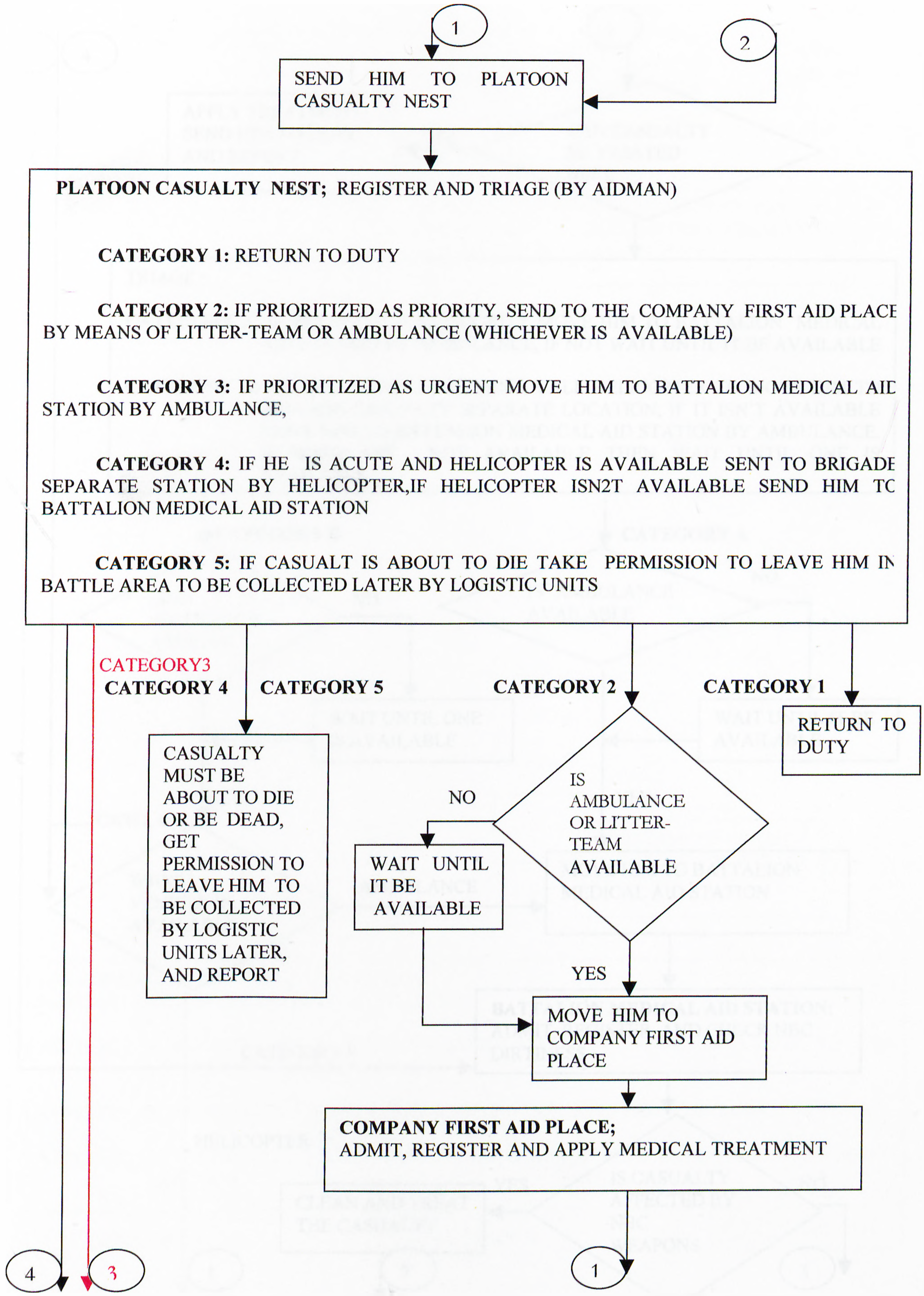

1
CATEGORY A
2
CATEGORY C
3
4
30-BED MOBILE SURGICAL HOSPITAL:
APPLY SURGICAL OPERATION , IF OPERATION IS SUCCESSFUL SEND HIM TO ARMY STATIONARY HOSPITAL IF NOT SEND TO CORPS 400-BED HOSPITAL
ARMY STATIONARY HOSPITAL;
MAKE THE GENERAL TREATMENT AND SEND HIM TO REGIONAL STATIONARY HOSPITAL AND REHABILITATION CENTER
CIVILIAN STATIONARY HOSPITAL;
MAKE THE GENERAL TREATMENT AND SEND HIM TO REGIONAL STATIONARY HOSPITAL AND REHABILITATION CENTER
REGIONAL STATIONARY HOSPITAL AND REHABILITATION CENTER
MAKE FINAL TREATMENT AND SEND BACK TO HIS DUTY

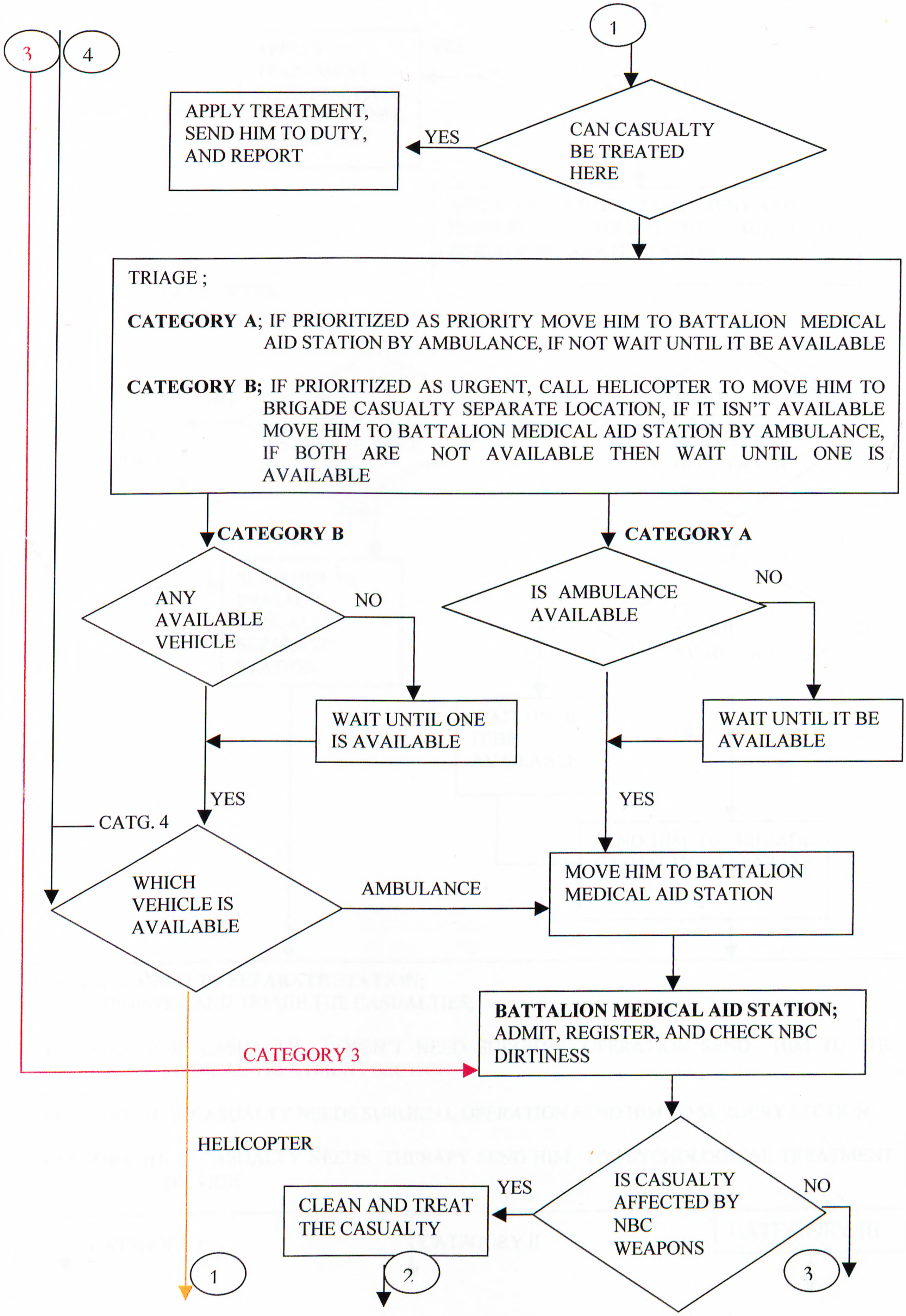
Detailed flow chart of the existing system:

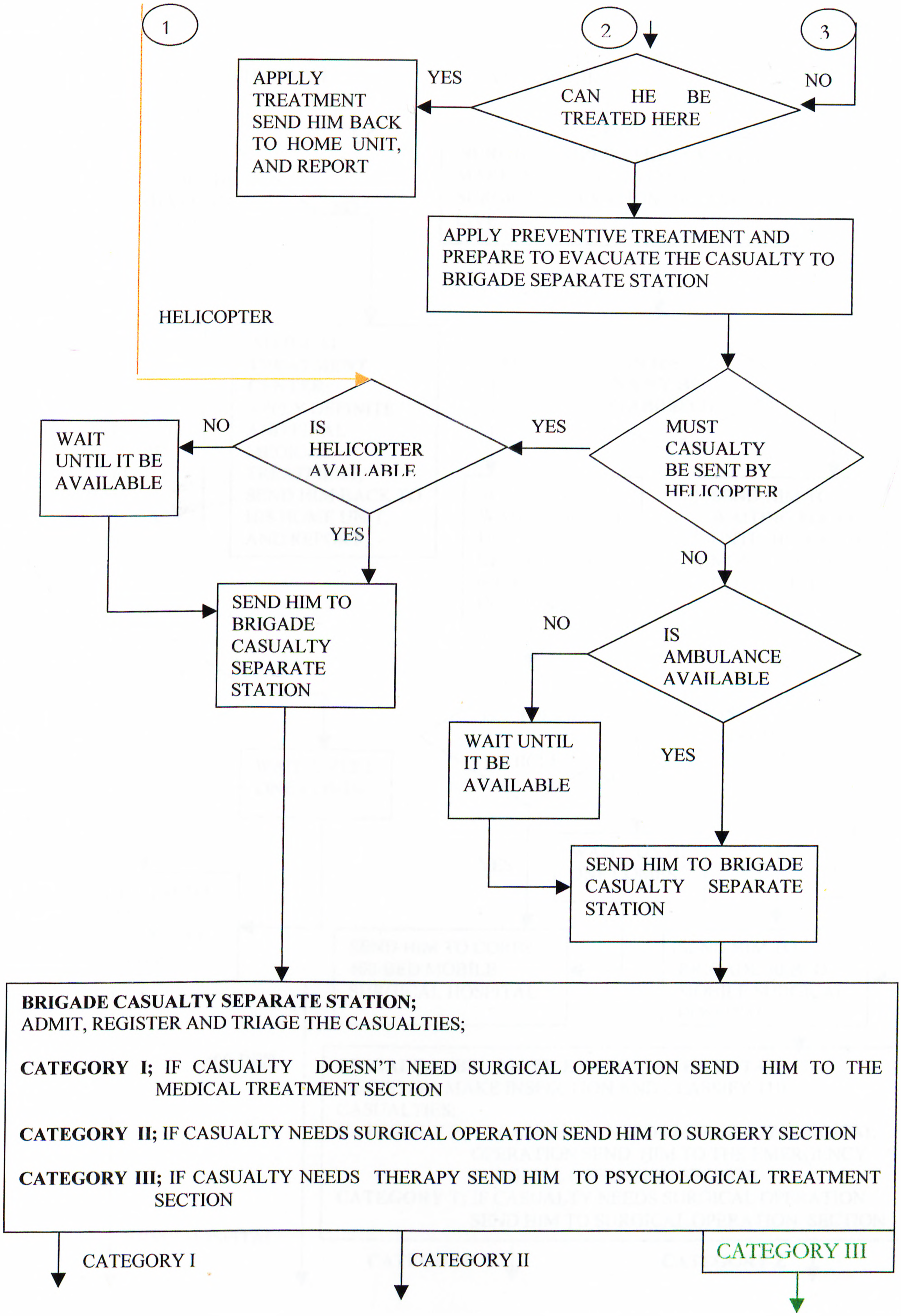
FLOW CHART OF CASUALTY EVACUATION OF BRIGADE IN DEFENCE OPERATION

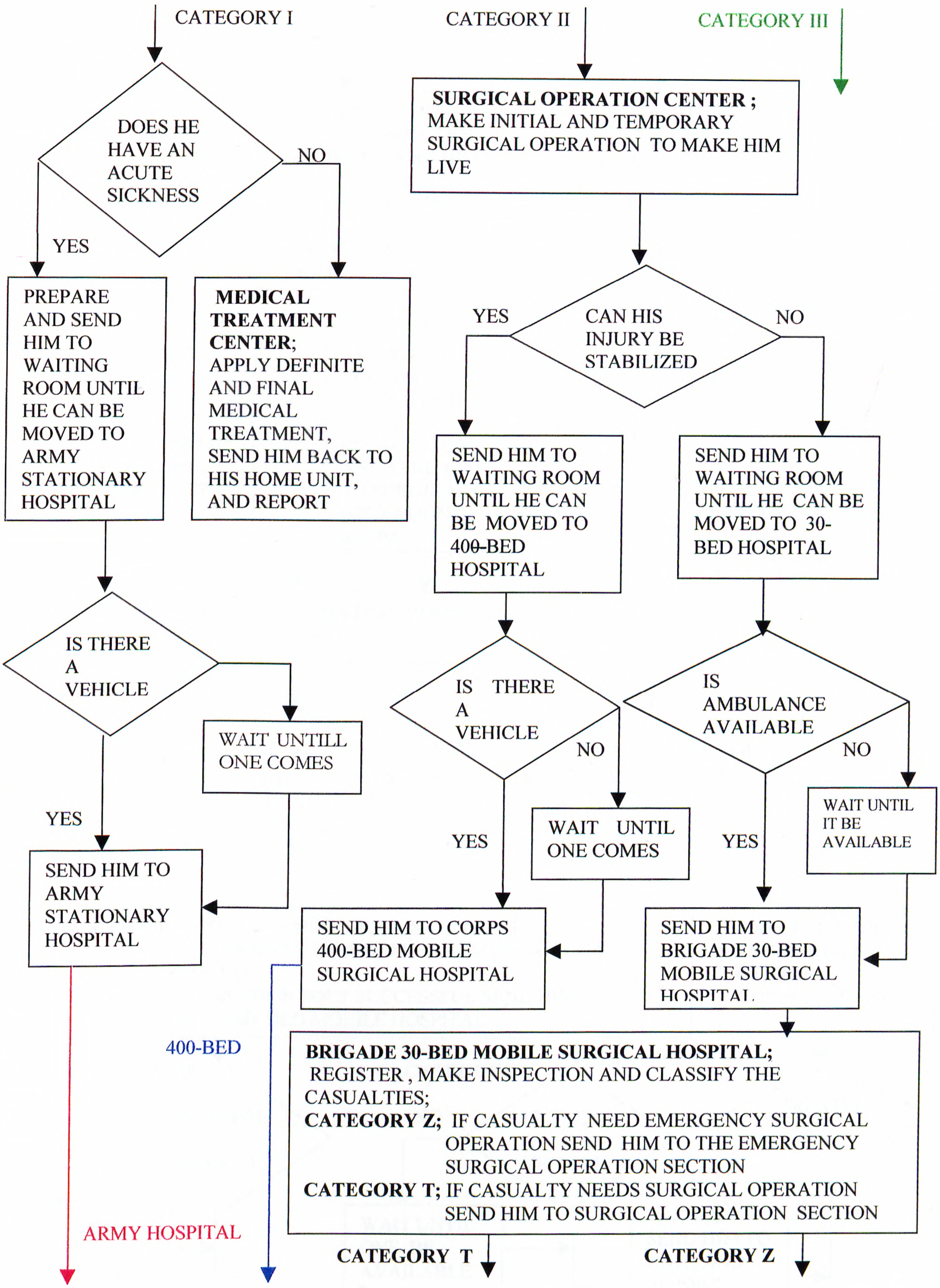


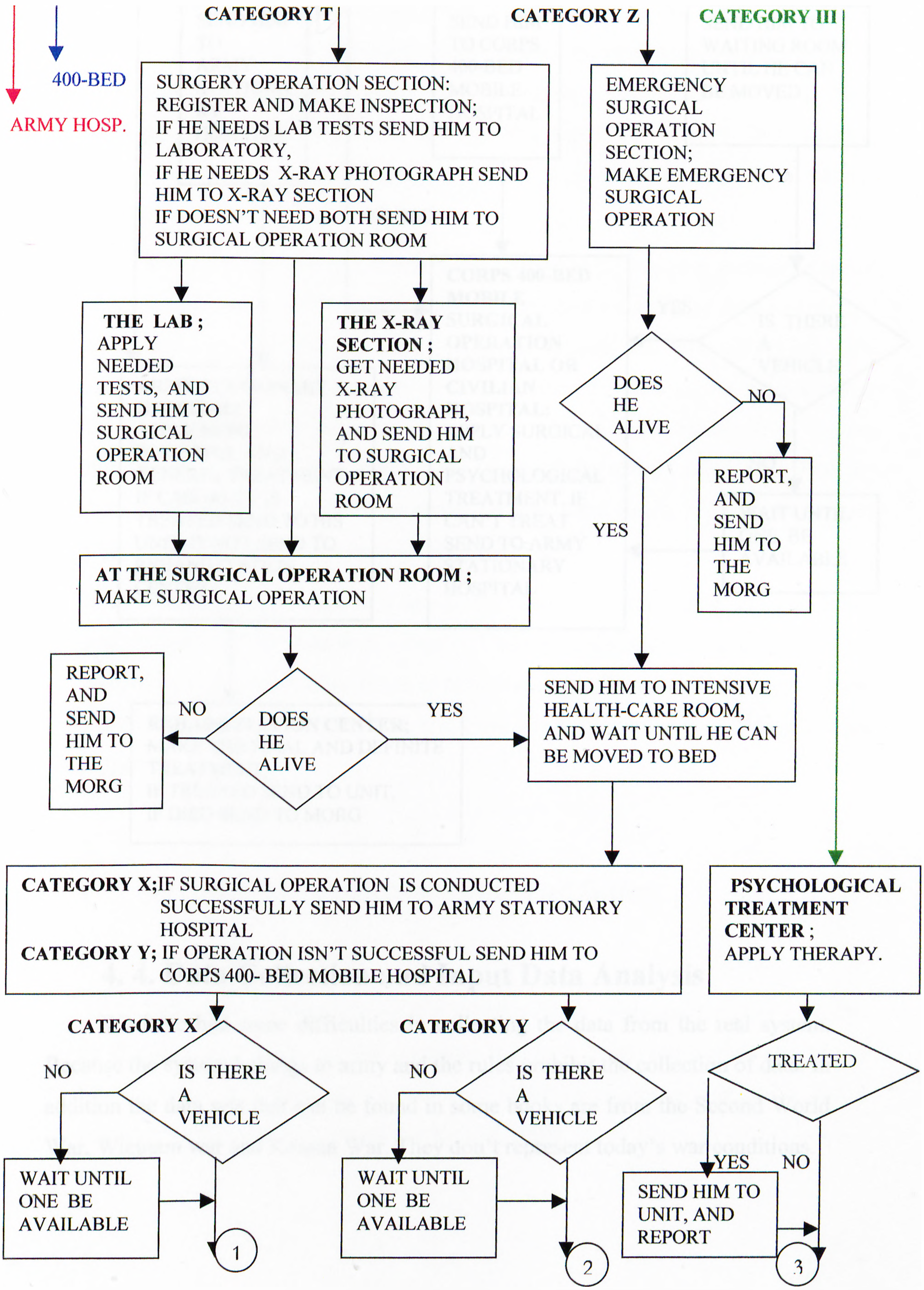

1
2
NO
MARK CASUALTY'S LOCATION
NO
IS AIDMAN AVAİLABLE
YES
NO
WAIT UNTIL THE TIME THAT HE BE AVAILABLE
APPLY MEDICAL TREATMENT
NO
CAN RETURN TO DUTY
YES
REPORT, AND SEND TO DUTY
NO
DOES THE SITUATION ALLOWS THE CASUALTY TO BE EVACUATED
WAIT UNTIL THE SITUATION ALLOWS HIM TO BE EVACUATED
YES
IS LITTER-TEAM AVAILABLE
NO
WAIT UNTIL IT BE AVAILABLE
YES
1
2


1
2
SEND HIM TO PLATOON CASUALTY NEST
PLATOON CASUALTY NEST; REGISTER AND TRIAGE (BY AIDMAN)
CATEGORY 1: RETURN TO DUTY
CATEGORY 2: IF PRIORITIZED AS PRIORITY, SEND TO THE COMPANY FIRST AID PLACE BY MEANS OF LITTER-TEAM OR AMBULANCE (WHICHEVER IS AVAILABLE)
CATEGORY 3: IF PRIORITIZED AS URGENT MOVE HIM TO BATTALION MEDICAL AID STATION BY AMBULANCE,
CATEGORY 4: IF HE IS ACUTE AND HELICOPTER IS AVAILABLE SENT TO BRIGADE SEPARATE STATION BY HELICOPTER,IF HELICOPTER ISN2T AVAILABLE SEND HIM TO BATTALION MEDICAL AID STATION
CATEGORY 5: IF CASUALT IS ABOUT TO DIE TAKE PERMISSION TO LEAVE HIM IN BATTLE AREA TO BE COLLECTED LATER BY LOGISTIC UNITS
CATEGORY3
CATEGORY 4
CATEGORY 5
CATEGORY 2
CATEGORY 1
RETURN TO DUTY
CASUALTY MUST BE ABOUT TO DIE OR BE DEAD, GET PERMISSION TO LEAVE HIM TO BE COLLECTED BY LOGISTIC UNITS LATER, AND REPORT
NO
IS AMBULANCE OR LITTER-TEAM AVAILABLE
WAIT UNTIL IT BE AVAILABLE
YES
MOVE HIM TO COMPANY FIRST AID PLACE
COMPANY FIRST AID PLACE; ADMIT, REGISTER AND APPLY MEDICAL TREATMENT
4
3
1

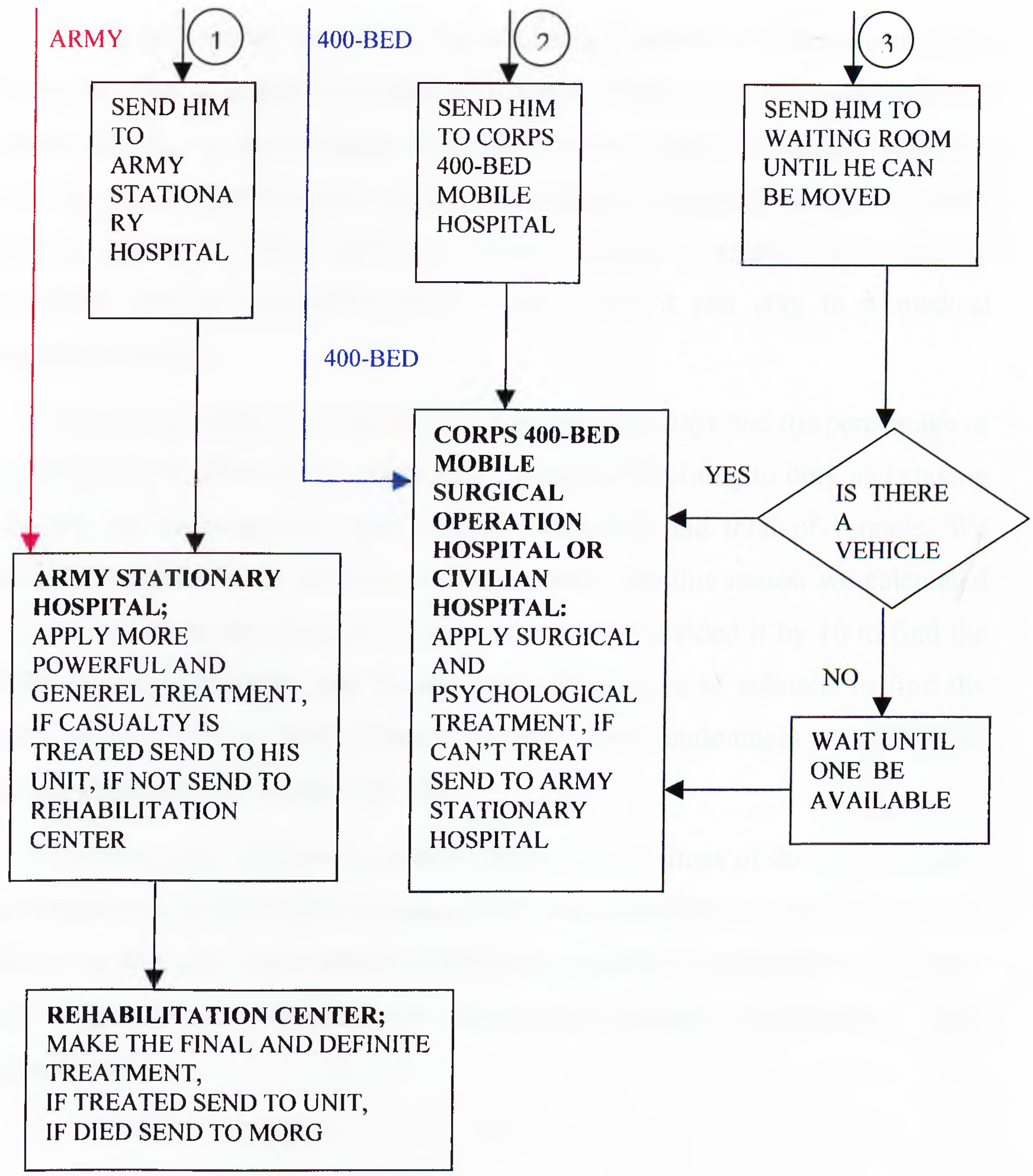

1
3
4
APPLY TREATMENT, SEND HIM TO DUTY, AND REPORT
YES
CAN CASUALTY BE TREATED HERE
TRIAGE ;
CATEGORY A; IF PRIORITIZED AS PRIORITY MOVE HIM TO BATTALION MEDICAL AID STATION BY AMBULANCE, IF NOT WAIT UNTIL IT BE AVAILABLE
CATEGORY B; IF PRIORITIZED AS URGENT, CALL HELICOPTER TO MOVE HIM TO BRIGADE CASUALTY SEPARATE LOCATION, IF IT ISN'T AVAILABLE MOVE HIM TO BATTALION MEDICAL AID STATION BY AMBULANCE, IF BOTH ARE NOT AVAILABLE THEN WAIT UNTIL ONE IS AVAILABLE
CATEGORY B
CATEGORY A
ANY AVAILABLE VEHICLE
NO
IS AMBULANCE AVAILABLE
NO
WAIT UNTIL ONE IS AVAILABLE
WAIT UNTIL IT BE AVAILABLE
YES
YES
CATG. 4
WHICH VEHICLE IS AVAILABLE
AMBULANCE
MOVE HIM TO BATTALION MEDICAL AID STATION
BATTALION MEDICAL AID STATION; ADMIT, REGISTER, AND CHECK NBC DIRTINESS
CATEGORY 3
HELICOPTER
YES
IS CASUALTY AFFECTED BY NBC WEAPONS
NO
CLEAN AND TREAT THE CASUALTY
1
2
3


1
2
3
APPLLY TREATMENT SEND HIM BACK TO HOME UNIT, AND REPORT
YES
CAN HE BE TREATED HERE
NO
APPLY PREVENTIVE TREATMENT AND PREPARE TO EVACUATE THE CASUALTY TO BRIGADE SEPARATE STATION
HELICOPTER
WAIT UNTIL IT BE AVAILABLE
NO
IS HELICOPTER AVAILABLE
YES
MUST CASUALTY BE SENT BY HELICOPTER
YES
NO
SEND HIM TO BRIGADE CASUALTY SEPARATE STATION
NO
IS AMBULANCE AVAILABLE
WAIT UNTIL IT BE AVAILABLE
YES
SEND HIM TO BRIGADE CASUALTY SEPARATE STATION
BRIGADE CASUALTY SEPARATE STATION;
ADMIT, REGISTER AND TRIAGE THE CASUALTIES;
CATEGORY I; IF CASUALTY DOESN'T NEED SURGICAL OPERATION SEND HIM TO THE MEDICAL TREATMENT SECTION
CATEGORY II; IF CASUALTY NEEDS SURGICAL OPERATION SEND HIM TO SURGERY SECTION
CATEGORY III; IF CASUALTY NEEDS THERAPY SEND HIM TO PSYCHOLOGICAL TREATMENT SECTION
CATEGORY I
CATEGORY II
CATEGORY III


CATEGORY I
CATEGORY II
CATEGORY III
DOES HE HAVE AN ACUTE SICKNESS
NO
YES
PREPARE AND SEND HIM TO WAITING ROOM UNTIL HE CAN BE MOVED TO ARMY STATIONARY HOSPITAL
MEDICAL TREATMENT CENTER; APPLY DEFINITE AND FINAL MEDICAL TREATMENT, SEND HIM BACK TO HIS HOME UNIT, AND REPORT
SURGICAL OPERATION CENTER ; MAKE INITIAL AND TEMPORARY SURGICAL OPERATION TO MAKE HIM LIVE
CAN HIS INJURY BE STABILIZED
YES
NO
SEND HIM TO WAITING ROOM UNTIL HE CAN BE MOVED TO 400-BED HOSPITAL
SEND HIM TO WAITING ROOM UNTIL HE CAN BE MOVED TO 30-BED HOSPITAL
IS THERE A VEHICLE
WAIT UNTILL ONE COMES
YES
SEND HIM TO ARMY STATIONARY HOSPITAL
IS THERE A VEHICLE
NO
YES
WAIT UNTIL ONE COMES
IS AMBULANCE AVAILABLE
NO
YES
WAIT UNTIL IT BE AVAILABLE
SEND HIM TO CORPS 400-BED MOBILE SURGICAL HOSPITAL
SEND HIM TO BRIGADE 30-BED MOBILE SURGICAL HOSPITAL
400-BED
BRIGADE 30-BED MOBILE SURGICAL HOSPITAL; REGISTER , MAKE INSPECTION AND CLASSIFY THE CASUALTIES;
CATEGORY Z; IF CASUALTY NEED EMERGENCY SURGICAL OPERATION SEND HIM TO THE EMERGENCY SURGICAL OPERATION SECTION
CATEGORY T; IF CASUALTY NEEDS SURGICAL OPERATION SEND HIM TO SURGICAL OPERATION SECTION
ARMY HOSPITAL
CATEGORY T
CATEGORY Z



CATEGORY T
CATEGORY Z
CATEGORY III
400-BED
ARMY HOSP.
SURGERY OPERATION SECTION:
REGISTER AND MAKE INSPECTION;
IF HE NEEDS LAB TESTS SEND HIM TO LABORATORY,
IF HE NEEDS X-RAY PHOTOGRAPH SEND HIM TO X-RAY SECTION
IF DOESN'T NEED BOTH SEND HIM TO SURGICAL OPERATION ROOM
EMERGENCY SURGICAL OPERATION SECTION;
MAKE EMERGENCY SURGICAL OPERATION
THE LAB ;
APPLY NEEDED TESTS, AND SEND HIM TO SURGICAL OPERATION ROOM
THE X-RAY SECTION ;
GET NEEDED X-RAY PHOTOGRAPH, AND SEND HIM TO SURGICAL OPERATION ROOM
DOES HE ALIVE
NO
YES
REPORT, AND SEND HIM TO THE MORG
AT THE SURGICAL OPERATION ROOM ;
MAKE SURGICAL OPERATION
REPORT, AND SEND HIM TO THE MORG
NO
DOES HE ALIVE
YES
SEND HIM TO INTENSIVE HEALTH-CARE ROOM, AND WAIT UNTIL HE CAN BE MOVED TO BED
CATEGORY X;IF SURGICAL OPERATION IS CONDUCTED SUCCESSFULLY SEND HIM TO ARMY STATIONARY HOSPITAL
CATEGORY Y; IF OPERATION ISN'T SUCCESSFUL SEND HIM TO CORPS 400- BED MOBILE HOSPITAL
PSYCHOLOGICAL TREATMENT CENTER ;
APPLY THERAPY.
CATEGORY X
NO
IS THERE A VEHICLE
CATEGORY Y
NO
IS THERE A VEHICLE
TREATED
YES
NO
WAIT UNTIL ONE BE AVAILABLE
WAIT UNTIL ONE BE AVAILABLE
SEND HIM TO UNIT, AND REPORT
1
2
3



4. 4. Data Collection and Input Data Analysis

We have had some difficulties in collecting the data from the real system. Because the system belongs to army and the rules prohibit the collection of data. In addition the data sets that can be found in some books are from the Second World War, Wietnam war and Korean War. They don't represent today's war conditions.

In this system we need data for number of patients of illness categories, interarrival time of patients, number of patients entering the system, number of patients returning to duty, number of patients dying, number of patients going on treatment in the system, service times of registry personnel, laboratory, NBC cleaning operator, X-ray operator, doctor, therapist, surgery and casualty evacuation principle (maximum period that a patient can stay in a medical treatment facility).

We could find data of casualties for a period of 10 days and the percentage of dead and injured soldiers (the collection of casualties returning to duty and staying in system for treatment) for each subunit of brigade and total of brigade. We couldn't find interarrival times of casualties either. For this reason we calculated the total number of casualties of 10 days and then we divided it by 10 to find the number of daily casualties and divided the result by rate of subunits to find the number of casualties of these subunits. To give them randomness we have used uniform distribution (See Appendix B).

We have gotten 6 doctor's opinion to find service times of doctors, surgeons and therapists for each kind of sickness. Then we calculated the average of them and find the average service times as minimum, most-likely and maximum values. Then to give them randomness we have used triangular distribution. (See Appendix A)

4. 5. Model Verification and Validation

4. 5. 1. Verification

Verification is determining that the simulation computer program performs as intended, ie. debugging the computer program. Thus verification checks the translation of the simulation model (eg. flow charts and assumptions) into a correctly working program (Law and Kelton, 1991).

To make verification we made flow chart, which includes each logically possible action the casualty evacuation system can take when an event occurs, and we follow the model logic for each action for each event type.

We examine the model output for reasonableness with the real datas that we have and with the experience of the expert of the subject from the School of Health Service and Support, Health Office Chief personal of the General Staff and the Army.

We have the computerized representation checked by First Lieutenant D. Hakan Utku and First Lieutenant Ali R. Tütüncüoğlu.

4.5. 2. Validation

Once the model was verified the next step was to validate it. Validation is the process of raising to an acceptable level of user's confidence that any simulation-derived inference about the system is correct (Pedgen, Shannon and Sadowski, 1995). Sargent (1984) explains some of the techniques used to validate a simulation model. Lowery and Martin (1992) applies validation techniques to a health care simulation model. Many of these validation approaches make use of statistical analysis. We applied these techniques for only three historical data due to the lack of sufficient historical data available. In addition, we used other techniques that involve the expert (related officers) directly in the validation process.

(1) Face Validity:

The model users of this simulation are the commanders of medic units, the chief of Health centers, the Health Service and Support School and the commanders of all units.

We made face validity with Major Adem Köse from the school of Health Service and Support and Captain Mustafa Özer from Health Office of the General Staff who are knowledgeable about the real system being simulated. We also made validity with potential users like different level units' commanders of army.

(2) Input-Output Validation: Using Historical Input Data

We used historical input data in the simulation. For that reason, we have real data to make comparison with patient numbers, but we don't have any real data to make comparisons related with time in and time in system values.

The real data that is available does not have a variance. For that reason, we construct a confidence interval for the simulation result and checked whether the real data is within this interval or not.

The results obtained from the simulation experiment and the real data are summarized in Table 3. In this table system enter represents the number of casualties and involves the sum of the number of patient in system and the number of dead. Patient in system involves the sum of the number of patient return to duty and the number of patient going on treatment.

	REAL DATA		SIMULATION EXPERIMENT	
	Mean Value	**Percentage**	**Mean Value**	**Percentage**
System Enter	1516	% 100	1485	% 100
Patient in System	1213	% 80	1175	% 79
Dead	303	% 20	309	% 21

Table 2. The comparison of result of simulation experiment with real data.

In the tableau below, we present the data set of input validity, output validity and validity of number of patient staying in system. Let us first explain these parameters:

Real mean value is the only one historical data of the number of patients entering in the system for input validity, the number of patients dead for the output validity and the number of patient staying in system for the validity of patient in system.

Simulation mean is the mean of related validation subject that we determine by taking average of 10 replications of the simulation model.

Validity Type	Real Mean	Simulation Mean	α	Sp	n	hl	t value
Input Validity	1516	1485	0.05	8.439	10	5.231	2.26
Output Validity	304	309	0.05	5.033	10	3.3	2.26
Patient In System	1213	1175	0.05	9.904	10	6.138	2.26

Table 3. Data set of input validity, output validity and validity of number of patient staying in system

Where,

Sp is the average standard deviation of related validation subject that we determine by taking average of 10 replications' result of simulation model.

α: We constructed a 100(1-0,05) percent confidence interval for each validity type by using average of 10 replications' results of simulation model.

n: We run the simulation model 10 times.

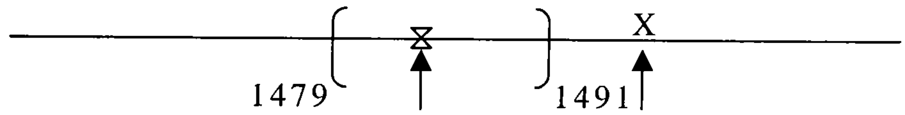
hl is half length which is equal to t value * square root of variance (standard deviation). We determine this result by using Excell program.

t value is determined from t distribution tableau by looking in (n-1) row and (1-α)/2 column.

(a) Input Validity

Confidence interval constructed at 95 % for the mean number of patients entering in the system is:

1485 ± 6



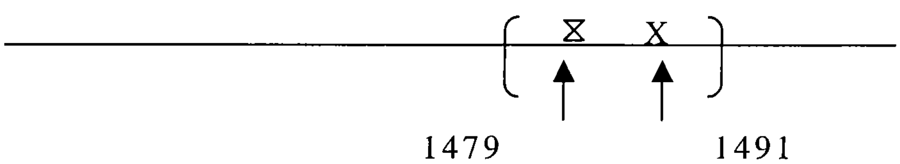
$\mu_y = 1485$ $\mu_x = 1516$

μ_x is the mean value of historical data

μ_y is the mean value of simulation result

As mentioned in (Özer, 2000) the historical data for nonbattle casualty changes from 0.09 % to 0.77 %. It is accepted as 1.35 % by Allied Commander of European NATO Force. There are very big differences between these rates. For this reason, 0.02 computing error is quite acceptable. In that case, new result will be:
1516 * 0.02 = 30

$$1516 - 30 = 1486$$



μ_y μ_x

Ho : $\mu_x = \mu_y$

Ha : $\mu_x \neq \mu_y$

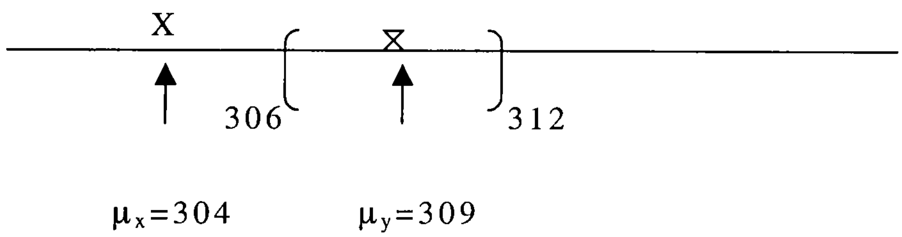
Ho assumes that the mean of historical data is equal to the mean of simulation result. Ha assumes that the mean of historical data is not equal to the mean of simulation result

In terms of the number of casualties entering the system, the mean value of real data is within the CI so we can accept that these two systems are statistically same. In other words, we fail to reject null hypothesis in favor of the two sided alternative hypothesis at $\alpha = 0.05$. This means that we did not observe a significant difference between μ_x and μ_y. As a result, we conclude that the model is, for practical purposes, a valid representation of the system.

(b) Output Validity

Confidence Interval constructed 95 % for mean of simulation result of the number of patients entering at the system:

309 ± 3.3

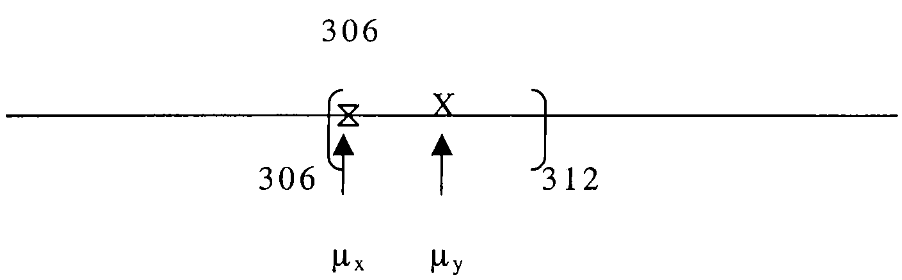


μ_x is the mean value of historical data

μ_y is the mean value of simulation result

We assumed that we have 0.01 computing error in our calculations of input datas. In that case, new result will be: $304 * 0.01 = 3$

$309 - 3 = 306$



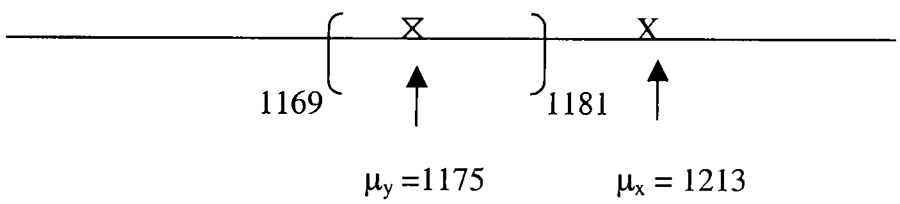
$Ho : \mu_x = \mu_y$

$Ha : \mu_x \neq \mu_y$

Ho assumes that the mean of historical data is equal to the mean of simulation result.Ha assumes that the mean of historical data is not equal to the mean of simulation result.

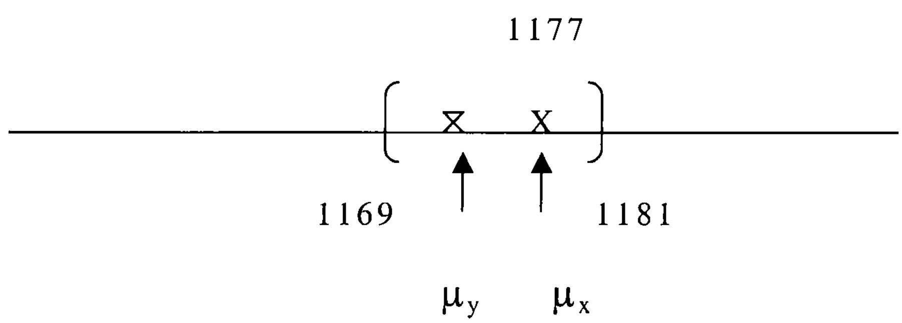
In terms of the number of dead, the mean value of real data is within the CI. Thus, we accept that these two systems are statistically same. In other words, we conclude that the model is, for practical purposes, a valid representation of the system.

(c) Validity of Patient in system (patient return to duty + patient going on treatment)



We assumed that we have 0.03 computing error in our calculations of input data. In that case, new result will be: 1213 * 0.03 = 36

1213 - 36 = 1177



Ho : $\mu_x = \mu_y$

Ha : $\mu_x \neq \mu_y$

Ho assumes that the mean of historical data is equal to the mean of simulation result. Ha assumes that the mean of historical data is not equal to the mean of simulation result.

For the number of patient staying in system measure, the mean value of real data is within the CI. Again we can accept the fact, that these two systems are statistically same. Hence, we conclude that the model is, for practical purposes, a valid representation of the system.

4.6. Output Data Analysis

In terms of simulation terminology, this system is terminating system, because there is a natural event E that specifies the length of each run. The goal of this simulation is to determine the final casualty numbers according to their types, procedure and system times of medical treatment facilities and medical persons when the battle ends. In this case E = {either the blue force or the red force has "won" the battle} (See the reference Law and Kelton, 1991, pp. 529). We made 10 replications for each alternative system for comparison of existing and proposed systems in approximately 7 minutes for each alternative system. As will be explained in the next chapter, we compare 6 alternative systems using the ranking and selection procedure (see reference Law and Kelton, 1991, pp. 596) and we made 20 replications for first stage and 30 replications for second stage of the procedure in approximately 3 hours. (See Appendix F and G)

Choosing Sample Size

Considering that a simulation model is always just an approximation to the corresponding real-world system, we always try to estimate simulation result as close to the desired accuracy as possible. For terminating systems, if replication size (n) is small, there will be significant coverage degradation. As n gets large, the coverage appears to be approaching desired accuracy, as guaranteed by the central limit theorem. For this purpose we need to determine the sample size required to make the coverage as close as the desired accuracy.

To calculate sample size of the system, the performance measures that are used are the treatment times, time in systems and waiting times in queues. For output analysis of this terminating system we will determine the needed replication number by using some samples of these performance measures. For this purpose we chose the performance measures of the bottlenecks that are determined by the analysis of the simulation results. These are time in brigade separate surgery section, time in system of brigade 30-bed hospital, and time in queue for the bed of brigade separate surgery.

We used the folowing equations (Law and Kelton, 1991):

To find the approximate value of starting size i, we use inequality :

$$i \geq S^2(n)\left[\frac{Z_{1-\frac{\alpha}{2}}}{\beta}\right]^2$$

We get required sample size by using the procedure :

$$n_a^*(\beta) = \min\left\{ i \geq n : t_{i-1,1-\frac{\alpha}{2}}\sqrt{\frac{S^2(n)}{i}} \right\} \leq \beta$$

Additional replications needed are determined by :

$$n_a^*(\beta) - n$$

We used absolute precision error (β) as the desired accuracy. If the estimate $\overline{X}$ is such that $|\overline{X} - \mu|$ then we say that the mean $\overline{X}$ has an absolute error of β. In our study, we wanted to get result of simulation model as close enough to the real system as possible. But when we choose a small desired accuracy we need large replication size which is impossible to apply in the sense of time cost. To show this difference between small desired accuracy and large desired accuracy in the tableau below we chose β as 10 minutes and 20 minutes for existing system. We observe that when we choose desired accuracy closer to the half length (hl), we get smaller additional replication size. If β were 1 minute the replication size would be more greater. We choosed desired accuracy as 10 minutes which is not a significant time in the sense of patient's waiting time in a health center queue or in the sense of process time of a health center.

By using this procedure we get the results presented in the table below. In Table 4, we give the results of three performance measures. These performance measures are critical measures in the system, namely time in brigade separate surgery section, time in system of brigade 30-bed hospital, and time in queue for bed of brigade separate surgery. Our initial replication size is 10. We use mean, variance and half-length that are determined by taking average of 10 replications. We assume that our estimate S^2 (n) of the population variance will not change as the number of replications increases (Law and Kelton, 1991, pp. 537). The required sample size for each simulation experiment is summarized in Table 4.

Performance Measures	Time in Brigade Separate Surgery			Time in System of 30-Bed Hospital		Time in Queue for Bed of Separate Station Surgery	
	Existing System		New System	Existing System	New System	Existing System	New System
Results	If β= 20 minutes	If β= 10 minutes					
No of Run	10	10	10	10	10	10	10
α	0.05	0.05	0.05	0.05	0.05	0.05	0.05
mean	7097.1	7097.1	5118.8	9144.57	3781.35	5232.55	2881.75
variance	1071.63	1071.63	3544.97	57689.55	8935.15	1015.69	13123.31
St. deviation	32.735	32.7358	59.54	240.2052	94.53	31.8699	114.56
Half length	20.2895	20.2895	36.902	148.8777	58.5866	19.7528	71.0017
β (Desired Accuracy)	20 minutes	10 minutes	10 minutes	10 minutes	10 minutes	10 minutes	10 minutes
i >= (starting replication size)	11	42	137	2217	344	40	505
I, (No of runs needed)	*13	*44	*137	*2217	*344	*42	505
hl ≤β	19.79	9.97	9.97	9.9989	9.989	9.93	9.99
Additional runs needed	3	34	127	2207	334	32	495

Table 4. Summary of optimal sample sizes

The meaning of β is as follows: When we choose β to be 10 minutes and α as 0.05 for time in brigade separate station surgery section, and if we construct 100 independent 95 percent confidence intervals using the above stopping rule, we would expect estimate the mean to have an absolute error of at most 10 minutes in about 95 out of the 100 cases (in about 5 cases the absolute error would be greater than 10 minutes). Note that we need 34 additional run for the existing system and 127 additional run for the proposed system. If β were 20 minutes we would need 3 additional run for the existing system. When we choose β to be 10 minutes for time in system of brigade 30-bed hospital, we need 2207 additional run for the existing system and 334 additional run for the proposed system. When we choose β to be 10 minutes for time in queue for bed of brigade separate station surgery section, we need 32 additional run for the existing system and 495 additional run for the proposed system. The results are very much different from each other, because we have no control over the confidence interval half-length; for fixed n, the half-length will depend on Var(X), the population variance of the X_i's.

CHAPTER 5

SIMULATION EXPERIMENT AND ANALYSIS OF RESULTS

This section presents the results of a statistical comparison of the existing system and the proposed systems for casualty evacuation of brigade in defence operation. We tested five alternative scenarios (alternative system designs) to see the behaviour of the systems under different conditions.

5.1. Implementation of Comparison of the Existing System with the Proposed System

To make a comparison of two systems, we use the performance measures such as time in brigade separate station's surgery section, time in system of 30-bed hospital, and time in queue for bed of brigade separate station's surgery section. We choose this performance metric, because they help to understand bottlenecks of the both existing system and proposed new system. In simulation experiments, we made 10 replications for each alternative system (ie., sample sizes n = n1 = n2 = 10). Since the variances of the alternatives are not equal, we used the Welch Approach to construct a confidence interval for the difference between the alternative systems. If the confidence interval contains zero, we say that there is no statistically significant difference between the systems. Otherwise, we declare one of them being the best depending on the sign of mean difference.

In general, the Welch's confidence interval is (Appendix L):

$$(\bar{X}-\bar{Y}) \pm t_{f,1-\frac{\alpha}{2}}\left[\frac{S_x^2}{m}+\frac{S_y^2}{n}\right]^{\frac{1}{2}}$$

Where, $\overline{X}$ is the mean of averages of observations from the first alternative simulation output at replication n, $\overline{Y}$ is the mean of averages of observations from the second alternative simulation output at replication n, S_x^2 is the variance of the first alternative, S_y^2 is the variance of the second alternative, f is degree of freedom, and $m = n = 10$ sample size (or number of replication).

The results of confidence intervals are given in Appendix E. The discussions of these results are given in the following sections.

5.1.1. Comparison of the Existing System with the Proposed System by Using Time in Surgery Section of Brigade Separate Station

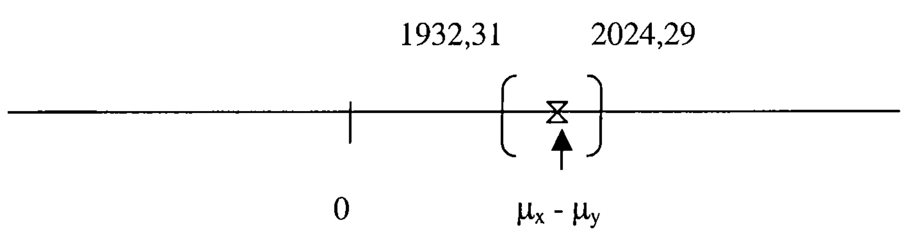
By using the simulation results given in Appendix E1, we test the following hypothesis.

Ho: $\mu_x = \mu_y$

Ha: $\mu_x \neq \mu_y$

Where μ_x is actual time in surgery section of brigade separate station of the existing system and μ_y is actual time in surgery section of brigade separate station of the proposed system. When we calculate the CI, we see that:

α	**f**	**t**	**95 % CI for $\mu_x - \mu_y$**
0.05	13.9857	2.140286	1978.3 ± 45.99



We reject the hypothesis since confidence interval for $\mu_x - \mu_y$ is totally to the right of zero. This means that there is strong evidence for the hypothesis that

$\mu_x - \mu_y > 0$, or equivalently $\mu_x > \mu_y$

This can be interpreted, as the new system is better than the existing system in the sense that proposed new system's separate surgery unit has smaller treatment time. In practice, it means that a patient will be treated in new system's surgery section approximately 33 hours earlier than he is treated in the existing system's surgery section. Since this difference is significant, the new system should be preferred to the existing system.

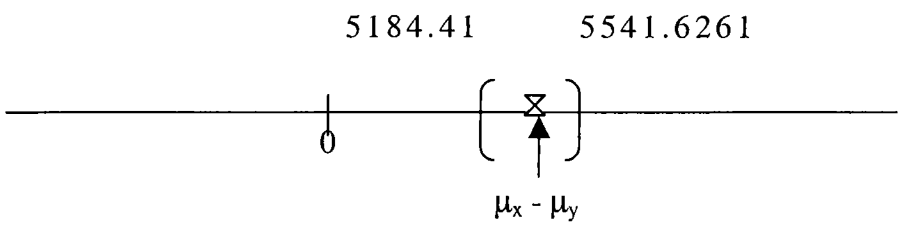
5.1.2. Comparison of the Existing System with the Proposed System by Using Time in System of 30-Bed Hospital

In this case, we have the same hypothesis test, but for a different performance measure, the simulation results are given in Appendix E2.

Ho : $\mu_x = \mu_y$

Ha : $\mu_x \neq \mu_y$

Where μ_x is actual time in system of brigade 30-bed hospital of the existing system, and μ_y is actual time in system of brigade 30-bed hospital of the proposed system.



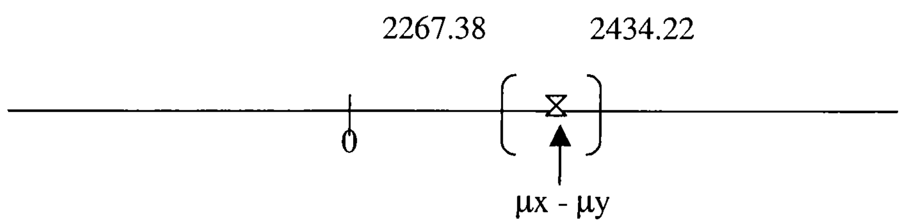
The results indicate that we should reject Ho since confidence interval for $\mu_x - \mu_y$ is totally to the right of zero. This means that there is strong evidence is that

$\mu_x - \mu_y > 0$, or equivalently $\mu_x > \mu_y$.

This can be interpreted, as the new system is better than the existing system in the sense that new system 30-bed hospital has smaller time-in-system than existing system 30-bed hospital does as desired. It means that the soldier will be treated in 30-bed hospital of new system in approximately 89 hours or 3.7 days earlier than he is treated in 30-bed hospital of the existing system after he is injured in battle area. Since this difference is significant, the new system should be again preferred to the existing system.

5.1.3. Comparison of the Existing System with the Proposed System by Using Waiting Time in Queue for Bed of Brigade Separate Station Surgery Unit

When the same statistical procedure is repeated for this performance measure (the simulation output data given in Appendix E3), we again reject the hypothesis. Since confidence interval for μ_x - μ_y is totally to the right of zero, there is strong evidence that $\mu_x - \mu_y > 0$, or equivalently $\mu_x > \mu_y$.



In other words, the proposed new system is better than the existing system in the sense that waiting time in queue for bed of brigade separate station surgery unit of new system is smaller than waiting time in queue for bed of brigade separate station surgery unit of existing system. Specifically, a patient will wait in queue for bed of brigade separate station surgery unit of new system 39 hours less than he waits in queue for bed of brigade separate station surgery unit of the existing system. Since this difference is significant, the new system should be preferred to the existing system.

5. 1. 4. Discussion of the Results

In this section, we compare the proposed new casualty evacuation policy of brigade with the existing casualty evacuation policy. These two systems have the same casualty procedure until battalion level, but after battalion level the procedure differs significantly as explained in Section 3.7. of Chapter 3. The results indicate that the proposed system is significantly better than the existing system in terms of treatment time, time in system, and waiting time in queue. But it is not clear if it is still good enough under different war conditions. This will be analyzed in Section 5.3.

5. 2. Implementation of Selecting the Best of k Systems

In this implementation, we compare 5 alternatives using three performance measures that are determined as the bottlenecks of the system after the analysis of the simulation results. These measures are time in brigade separate station's surgery section, time in system of brigade 30-bed hospital and time in queue for bed of brigade separate station's surgery section. We determined the best of five alternatives by using Dudewicz and Dalal (1975) "two-stage" procedure.

5.2.1. Selecting the Best of 5 Alternatives

The first alternative is the existing system. The second alternative is the proposed new system. The difference between these two systems is that, in the proposed system the patients can be sent from battalion medical aid station to all the higher level medical facilities, but in the existing system the patient must be sent to brigade separate station after battalion medical aid station. The third alternative is the revised version of the existing system. In this system, the number of bed of separate station medical treatment section is increased from 9 to 30, number of bed of separate station therapy unit is increased from 9 to 10 and number of bed of separate station surgery section is increased from 12 to 60. The fourth alternative is the revised version of the existing system such that the number of doctor of separate station medical treatment unit is increased from 1 to 2. The fifth alternative is the revised version of the proposed system such that the number of bed of separate station medical treatment section is increased from 9 to 15, number of bed of separate station therapy section is increased from 9 to 10 and number of bed of separate station surgery section is increased from 12 to 35. Let us now consider k different competing alternatives. A natural question to ask is: Which of these k systems is "best" system?

Let Xij be the random variable of interest from the jth replication of the ith system, and let (i =E (Xij). The Xij' s are all assumed to be independent of each other, i.e., the replications for a given alternative are independent, and runs for different alternatives are also to be made independently.

	Run 1	Run 2			Run n	
Alt. 1	X_{11}	X_{12}	...	...	X_{1n}	$\rightarrow \mu_1$
Alt. 2	X_{21}	X_{22}	...	...	X_{2n}	$\rightarrow \mu_2$
...	...	...	...	...	...	...
Alt. k	X_{k1}	X_{k2}	...	...	X_{kn}	$\rightarrow \mu_k$

Figure 1. Simulation model of the k alternatives

Alternatives are run without Common Random Number to avoid correlation among multiple runs. Xij might be obtained from replications if the system is terminating.

Xij: result of jth replication from ith alternative.

(eg., X14 : Average waiting time of the 1 st alternative bed queue of the 4 th replication)

$$\bar{X}_i = \frac{1}{n}\sum_{j=1}^{n} X_{ij}$$

where, $\bar{X}_1$ and $\bar{X}_2$ are expected performance of alternative 1 and 2 respectfully, and μ_1 and μ_2 are actual performance of alternative 1 and 2.

According to the central limit theorem, we know that

$$\bar{X}_1 = \mu_1 \xrightarrow{as} n \to \infty$$

$$\bar{X}_2 = \mu_2 \xrightarrow{as} n \to \infty$$

$$\bar{X}_k = \mu_k \xrightarrow{as} n \to \infty$$

Suppose that we deal with waiting times then if we rank the expected and average waiting times from smallest to largest, we obtain:

$\mu_1 \leq \mu_2 \leq \mu_3 \leq \ldots \leq \ldots \leq \ldots \leq \mu_k$

Where, μ_1 is the best system for this example.

μ_1 and mean X_1 may not refer to the same system due to the variability and inherent randomness in the systems. That means that there is some probability to fail to select the true (actual) best system.

Indifference-Zone Selection Approach:

In a stochastic simulation a "correct selection" can never be guaranteed with certainty. A compromise solution offered by indifference-zone selection is to guarantee to select the best system with high probability whenever it is at least a user specified amount better than the others; this "practically-significant" difference is called the indifference zone (Goldsman and Nelson 1994). Law and Kelton (1991) describe a number of indifference-zone procedures that have proven useful in simulation.

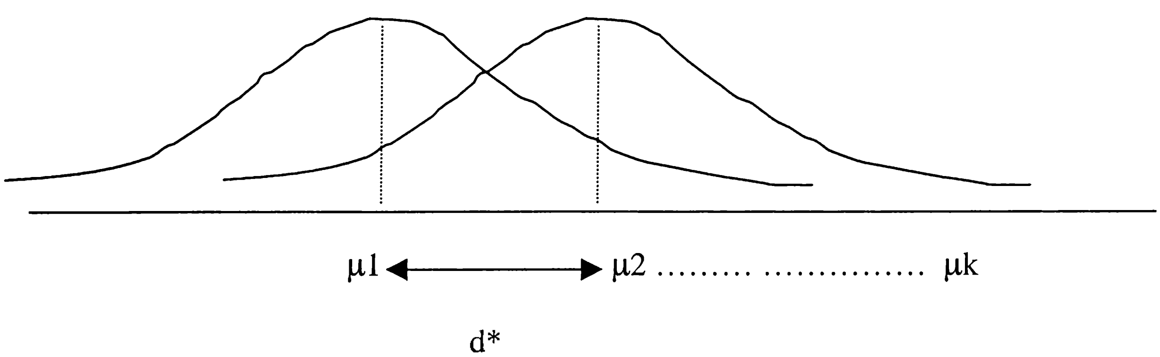


Figure 2. Indifference zone

d^* is called "Indifference zone" or "Indifference amount" between μ_1 and μ_2, and is independent of $\mu 1$ and $\mu 2$.

If μ_2.- $\mu_1 \leq d^*$ no problem

If $\mu_2 - \mu_1 > d^*$ we have a problem, we fail to select the best system.

Definitions:

CS = Correct Selection

P(CS) = Probability of correct selection

P* = Desired probability of correct selection

Statement: The exact problem formulation is that we want $P\ (CS) \geq P^*$ provided that $\mu_2 - \mu_1 \geq d^*$ where minimal CS probability $P^* > 1/k$ and the "indifference" amount $d^* > 0$ are both specified by the analyst.

What happens if $\mu_2 - \mu_1 \leq d^*$. The procedure by Dudewicz and Dalal stated below has the nice property that, with probability at least P^*, the expected response of the selected system will be no larger than $\mu_1 + d^*$. Thus, we are protected (with probability at least P*) against selecting a system with mean that is more than d* worse than that of the best system (Law and Kelton, 1991).

The statistical procedure for solving this problem, developed by Dudewicz and Dalal (1975) involves "two-stage" sampling from each of the k systems. In the first stage we make a fixed number of replications of each system, then use the resulting variance estimates to determine how many more replications from each system are necessary in a second stage of sampling in order to reach a decision (Dudewicz and Dalal 1975).

Conditions:

- It must be assumed that the X_{ij}' s are normally distributed
- Independent samples are used

The procedure is robust to departure from the normality assumption and it works with unknown and unequal variances.

This procedure involves two stages of independently replicating each of the k scenarios to be compared. In the first stage of simulating the l th scenario, a user-specified number of runs $n_{0\ \mathrm{must}}$ be performed; then the resulting sample variance estimate is used to determine how many additional runs of that scenario are needed in the second stage of the procedure. In the second stage of simulating the l th scenario, we perform $N_l - n_0$ additional runs to obtain the second-stage sample mean.

We run the simulation model of each alternative system for 20 replications and obtain the following results for each performance measure. The results are presented in Appendices F and G. In Appendix F1 we presented simulation results of 20 replications of time in brigade separate station's surgery section for 5 alternatives. In Appendix F2 we presented the results of 20 replications of time in system of brigade 30-bed hospital for 5 alternatives. In Appendix F3 we presented the results of 20 replications of time in queue of brigade separate station surgery section bed. In Appendix G1, we have the simulation results of additional replications for the 2nd stage of time in brigade separate station's surgery section. In Appendix G2, we presented the simulation results of additional replications for the 2nd stage of time in system of brigade 30-bed hospital. In Appendix G3, we presented the simulation results of additional replications for the 2nd stage of time in queue for bed of brigade separate station's surgery section.

In each table below, i represents the alternative. X_{i20} represents average performance measure of i th alternative of 20 replications in minutes, ***Var(20)*** represents the variance of 20 replications, N_i represents number of needed replication length, $X_{i(Ni-20)}$ represents average performance measure of i th alternative of additional replications in minutes, w_{i1} represents weight for i th alternative of stage 1, w_{i2} represents weight for i th alternative of stage 2, X_i represents weighted average of i th alternative in minutes.

5. 2. 2. Time in Brigade Separate Station Surgery Section

We have the following parameters:

$P^* = 0.95$ $n_0 = 20$ $k = 5$ $d^* = 20$ minutes

$h_1 = 3.258$ (from table 10.11 in Appendix 10B of Law and Kelton ,1991)

i	X_{i20}	Var (20)	N_i	$X_{i\,(Ni-20)}$	w_{i1}	w_{i2}	X_i
1	7074.37	1089.92	29	7034.83	0.7136	0.2864	7063.05
2	5039.65	9117.45	242	4920	0.0868	0.9132	4930.38
3	3006.01	150.026	21	3002.2	0.5	0.5	3004.15
4	3020.48	928.407	25	2999.9	0.849	0.151	3017.36
5	2902.54	1024.02	28	2919.59	0.793	0.207	2911.91

Table 5. Summary of results of selecting the best of 5 alternative system designs 1.

As you can see from the table, the second alternative needs 222 additional replication (N_i-n_0= 242-20=222). We used 30 replications to calculate X_{i2} to save from time-cost. We choose d* = 20 minutes to avoid making a large number of replications.

Now we can put the weighted sample means in order:

$X_5 < X_3 < X_4 < X_2 < X_1$

Since X_5 is the smallest weighted sample mean, we select Alternative 5 as having the minimum treatment time. We also observe that X_3 and X_4 are very close to each other. The results indicate that increasing number of doctor doesn't have a significant effect on the treatment time of brigade separate station's surgery section. The worst alternative is the existing system as having approximately 2.5 times greater treatment time than the revised proposed system. The 5 th Alternative has the smallest treatment time of separate station surgery section among 5 alternatives. When a patient enters in the brigade separate station's surgery section, he will be treated in 48 hours or 2 days involving post-treatment time in ward, and he will be sent to either duty or to one of the higher level health centers. We expect him to be treated minimum in one day, most likely in 2 days and maximum in 3 days. For this reason, we can accept the 5 th alternative as the best alternative system design.

5. 2. 3. Time in System of 30-Bed Hospital

Again, we have the following parameters:

P* = 0.95 k =5

n_o = 20 d* =120 minutes

h1 = 3.258 (from table 10.11 in Appendix 10B of Law and Kelton ,1991)

We choose $d^* = 120$ minutes to avoid making a large number of replications. Because the value of variances are very high.

	X_{i20}	Var (20)	N_i	$X_{i\,(Ni-20)}$	W_{i1}	W_{i2}	X_i
1	9036.04	39930.4	30	8883.38	0.732	0.268	8995
2	3754.18	7430.06	21	3632.2	0.5	0.5	3693.19
3	6424.44	5237.08	21	6503.9	0.5	0.5	6464.17
4	6639.45	15702.2	21	6614.6	0.5	0.5	6627.025
5	3455.68	8021.6	21	3566.7	0.5	0.5	3511.19

Table 6. Summary of results of selecting the best of 5 alternative system designs 2

Now we can put the weighted sample means in order:

$X_5 < X_2 < X_3 < X_4 < X_1$

Since X_5 is the smallest weighted sample mean, we select the 5 th alternative system since it yields the minimum time in system of 30-bed hospital. The worst alternative is the existing system as being about 2.5 times greater than the revised proposed system. Proposed system's weighted sample mean value is very close to the fifth alternative's weighted sample mean value. The 5 th alternative has the smallest time in system of brigade 30-bed hospital among 5 alternatives. After he is injured in battle area, the soldier will be treated in 30-bed hospital of 5 th Alternative in approximately 58 hours or 2.4 days involving post-treatment time in ward and he will be sent to either duty or to one of the higher level health centers. We expect casualty to be treated minimum in one day, most likely in 2 days and maximum in 3 days in brigade 30-bed hospital without involving time in unit level and time in brigade separate station. For this reason, we accept the 5 th alternative as the best system.

5.2.4. Waiting Time in Queue for Bed of Separate Surgery

We have the following parameters:

$P^* = 0.95$ $k = 5$ $n_o = 20$ $d^* = 20$ minutes

h1 = 3.258 (from table 10.11 in Appendix 10B of Law and Kelton ,1991)

I	X_{i20}	Var (20)	N_i	$X_{i\,(Ni-20)}$	W_{i1}	W_{i2}	X_i
1	5215.47	832.07	23	5173.57	0.938	0.062	5212.89
2	2757.6	23905.9	635	2561.63	0.037	0.963	2568.87
3	15.871	81.27	21	9	0.5	0.5	12.435
4	19	214.89	21	8	0.5	0.5	13.5
5	0.2285	0.0357	21	0.2827	0.5	0.5	0.2556

Table 7. Summary of results of selecting the best of 5 alternative system designs 3

Now we can put the weighted sample means in order:

$X_5 < X_3 < X_4 < X_2 < X_1$

Since X_5 is the smallest weighted sample mean, we select the 5 th alternative as having the minimum waiting time in separate surgery bed queue. The worst alternative is the existing system as being approximately 20000 times greater than the revised proposed system. The third and fourth systems' values are also better values than the existing system. The 5 th alternative has the smallest time in queue of brigade separate station's surgery section's bed among 5 alternatives. A patient will wait in queue for bed of brigade separate station's surgery unit of the 5 th alternative in less than 1 minute. In other words, when the patient leaves the surgery desk he will be in one of the ward's beds in less than 1 minute. In practice, he will not wait in the bed queue. As a result of this we can say that the 5 th alternative is a very good alternative.

5. 2. 5. Discussion

In this section we compared five alternatives and we have selected the best of five alternative systems. We apply "two-stage" procedure for three different performance measures, time in separate surgery, time in system of 30-bed hospital, and time in queue for bed of separate surgery unit.

At the end of three comparisons, we observe that the revised proposed system has the smallest weighted sample means. The main problem of both the existing system and the proposed new system is the number of bed's being insufficient. When we increase the number of the beds we reduce time in system, treatment time and waiting time. We also observe that the 5 th alternative is the best system, because it has the smallest treatment time of separate station surgery section, smallest time in system of brigade 30-bed hospital and the smallest waiting time in queue for bed of separate station surgery section. When we compare the 3 rd alternative with the 5 th alternative in terms of bed number, we observe that the 5 th alternative is better than the 3 rd alternative. Since we use totally 60 beds in Separate Station of the 5 th alternative while we are using totally 100 beds in Separate Station of the 3 rd alternative. Thus, we conclude that the 5 th alternative is the best.

5.3. Analysis of the Alternative Scenarios under Increased Arrival Rates

We also want to see behaviour of the existing system and proposed new system under the increased arrival rates. By doing this experimentation, we want to observe if the existing system and the proposed system are working well with the increased arrival rates. If the existing system or the proposed system do not work properly, what can we do to solve this problem? We also want to give answer to this question by performing some simulation experiments. The results of these simulation experiments are presented in tables in Appendix HA. To achieve this goal, we created three scenarios for the existing system and three scenarios for the proposed system.

The scenarios of the existing system are: First scenario is the existing system (Scenario 1). The second scenario is the existing system but its arrival rate is doubled (Scenario 2). Third Scenario is the existing system with three times increased arrival rate (Scenario 3).

The scenarios of the proposed system are: First scenario is the proposed system (Scenario 4). Second scenario is the proposed system but its arrival rate is increased twice (Scenario 5). Third scenario is the proposed system with three times increased arrival rate (Scenario 6).

We run the simulation model of each scenario for 10 replications. We determined the bottlenecks on problem areas in each scenario. Finally, we made graphical comparison of scenarios for each performance measure.

After running the simulation model of each scenario, we obtained the results for each performance measure and tabulated them in Appendix H. When we analyze these results; we determine critical measures in three groups. First group (Group 1) is the time in queue of first battalion's doctor and the time in queue of second battalion's doctor, second group (Group 2) is the time in queue for bed of separate station's medical treatment unit, the time in queue for bed of separate station's psychotherapy unit, the time in queue for bed of separate station's surgery unit, the time in queue for bed of 30-bed hospital emergency surgery unit and the time in queue for bed of 30-bed hospital normal surgery unit, third group (Group 3) is the time in queue for operator of 30-bed hospital's normal surgery unit and the time in queue for operator of 30-bed hospital's emergency surgery unit.

5. 3. 1. Group 1 (Time in Queue of First Battalion's Doctor)

We present the simulation results of the existing system for the time in queue (average waiting time) of first battalion's doctor in Appendix H1, for the number of patients in queue (NQ) in Appendix H8. As can be seen in the Appendix H1, when we increase the arrival rate by twice, there is no problem in the first battalion's doctor queue. The average waiting time of Scenario 1 is 11 minutes and average waiting time of Scenario 2 is 15 minutes. This result indicates that when arrival rate increases by two times there is no significant difference between the first and second scenarios. But when the increase is three times, the average waiting time becomes 113 minutes (from 11 minutes) and the average number of patient in the queue becomes 11 (from 1 patient). This is about 10 times greater than first two scenarios of the existing system (Figure 3).

This significant increase in waiting time can be reduced by increasing the doctor capacity from 1 to 2. After this change, as can be seen from Appendix L1A, the average waiting time in queue of First Battalion's doctor reduced to 2 minutes. Moreover, the average number of patient waiting in queue is almost zero (Appendix H8A).

When the simulation experiments are repeated for the proposed system, we obtain results such that the time in queue of first battalion's doctor in Scenario 4 is 11 minutes, in Scenario 5 is 13 minutes and in Scenario 6 is 171 minutes and the average number of patient in queue in Scenario 4 is almost zero, in Scenario 5 is 1 and in Scenario 6 is 17. The time in queue is approximately 60 minutes greater than the existing system. We can conclude that there is no significant improvement due to the use of proposed system compared to the existing system at the battalion level.

This significant increase in waiting time at the proposed system in Scenario 6 can be reduced by increasing the doctor capacity from 1 to 2. After this change, as can be seen from Appendix H1A, the average waiting time in queue of First Battalion's doctor reduced to about 2 minutes. Moreover, the average number of patient waiting in queue is almost zero (Appendix H8A).

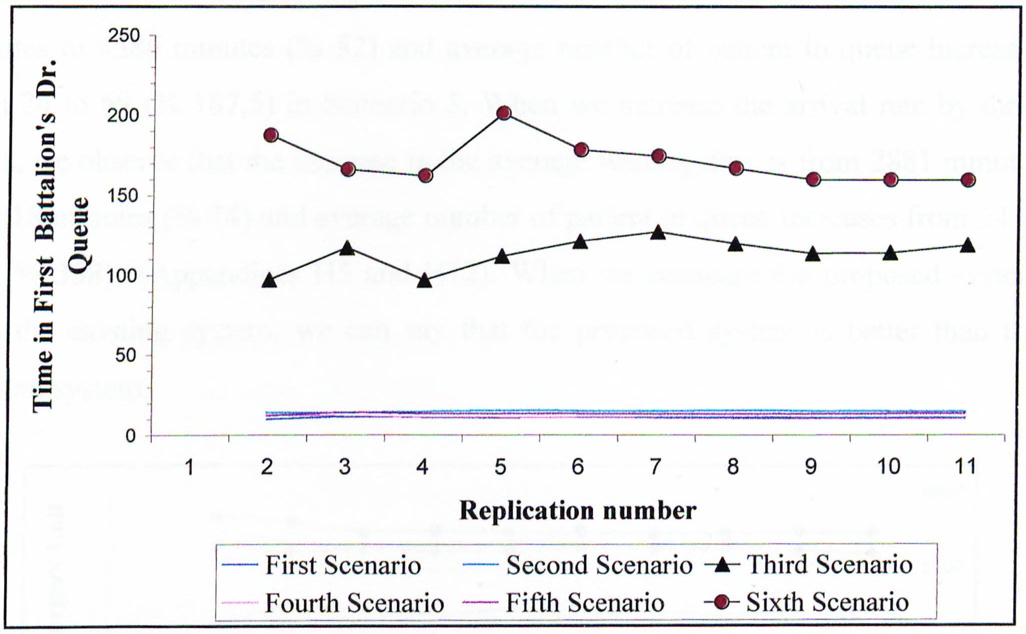


Figure 3. Time in Queue of First Battalion Doctor

For both of the existing system and the proposed system, increasing number of doctor will add a cost to the health service and support system, but this is feasible in war conditions, because the civilian doctors will be called to army in war conditions.

When we analyze the results of the scenarios for the second battalion's doctor, we obtain the similar results, because the second battalion has the same properties and the same problems. Both of them are on the main battle area and the weight of enemy threat over them are the same.

5.3.2. Group 2 (Time in Queue for Bed of Brigade Separate Station's Surgical Operation Unit)

As can be seen in Appendices H5 and H12, when the arrival rate is increased by 2 times, the average waiting time increases from 5232 minutes to 5394 minutes (% 3.1) and average number of patient in queue increases from 97 to 122 (% 25). When we increase the arrival rate by three times, we observe that the increase in the average waiting time is from 5232 minutes to 5502 minutes (% 5.1) and average number of patient in queue increases from 97 to 135 (% 39). This phenomenon is depicted in Figure 4.

When the simulation experiments are repeated for the proposed system and the arrival rate is increased by 2 times, the average waiting time increases from 2881 minutes to 4386 minutes (% 52) and average number of patient in queue increases from 24 to 69 (% 187,5) in Scenario 5. When we increase the arrival rate by three times, we observe that the increase in the average waiting time is from 2881 minutes to 5018 minutes (% 74) and average number of patient in queue increases from 24 to 110 (% 358) (Appendices H5 and H12). When we compare the proposed system with the existing system, we can say that the proposed system is better than the existing system.

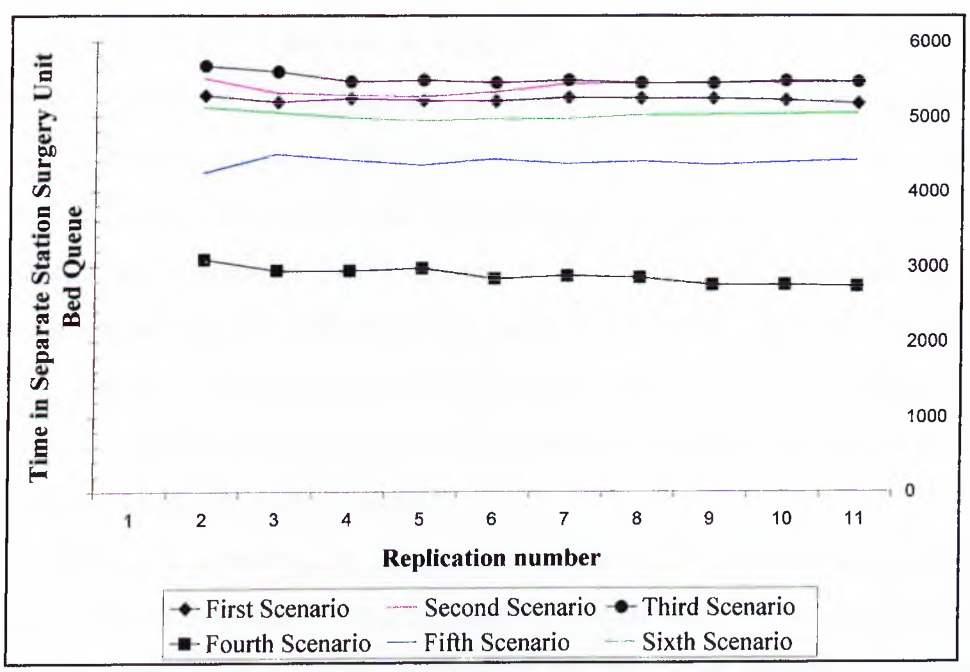


Figure 4. Time in Queue for Bed of Brigade Separate Station Surgery Unit

Generally speaking, both in the existing system and the proposed system, the numbers, i.e., 5232, 5394, 5502, 2881, 4386, and 5018 minutes are too high. In other words, the army cannot tolerate 3.6, 3.74, 3.8, 2, 3, and 3.5 days waiting in the queue of bed. To solve this problem, we propose to increase number of beds from 9 to 60, 9 to 68, 9 to 70, 9 to 30, 9 to 52, and 9 to 71 for Scenario 1, Scenario 2, Scenario 3, Scenario 4, Scenario 5, and Scenario 6, respectively.

After this change, as can be seen from Appendix H5A, the average waiting time in queue for bed of separate station's surgery unit reduced to reasonable values such as 13 minutes, 16 minutes, 12 minutes, 4 minutes, 22 minutes, and 2 minutes for Scenario 1, Scenario 2, Scenario 3, Scenario 4, Scenario 5, and Scenario 6, respectively. Moreover, the average number of patient waiting in queue is now almost zeroing for all scenarios (Appendix H12A).

This result indicates that increasing number of bed as explained in this paragraph decreases the waiting time in queue for bed and number of patient waiting in the queue to their reasonable values.

5.3.3. Group 3 (Time in Queue for Operator of Brigade 30-Bed Hospital's Normal Surgical Operation Unit of the Proposed System)

We present the simulation results for the time in queue (average waiting time) for operator of 30-bed hospital normal surgery unit in Appendix H6, for the number of patients in queue (NQ) in Appendix H13. As can be seen in Appendices H6 and H13, when the arrival rate is increased by 2 times, the average waiting time increases from 74 minutes to 698 minutes (% 843) and average number of patient in queue increases from 1 to 9. When we increase the arrival rate by three times, we observe that the increase in the average waiting time is from 74 minutes to 2219 minutes (% 2898) and average number of patient in queue increases from 1 to 42. This behaviour is depicted in Figure 5.

Generally speaking, in the proposed system, the numbers such as 698 and 2219 minutes in Scenario 5, and Scenario 6 are too high. Again the army cannot tolerate 12 hours and 1.5 days waiting in the queue of operator. To solve this problem, we propose to increase number of surgeon from 1 to 2, 1 to 3 for Scenario 5 and Scenario 6, respectively.

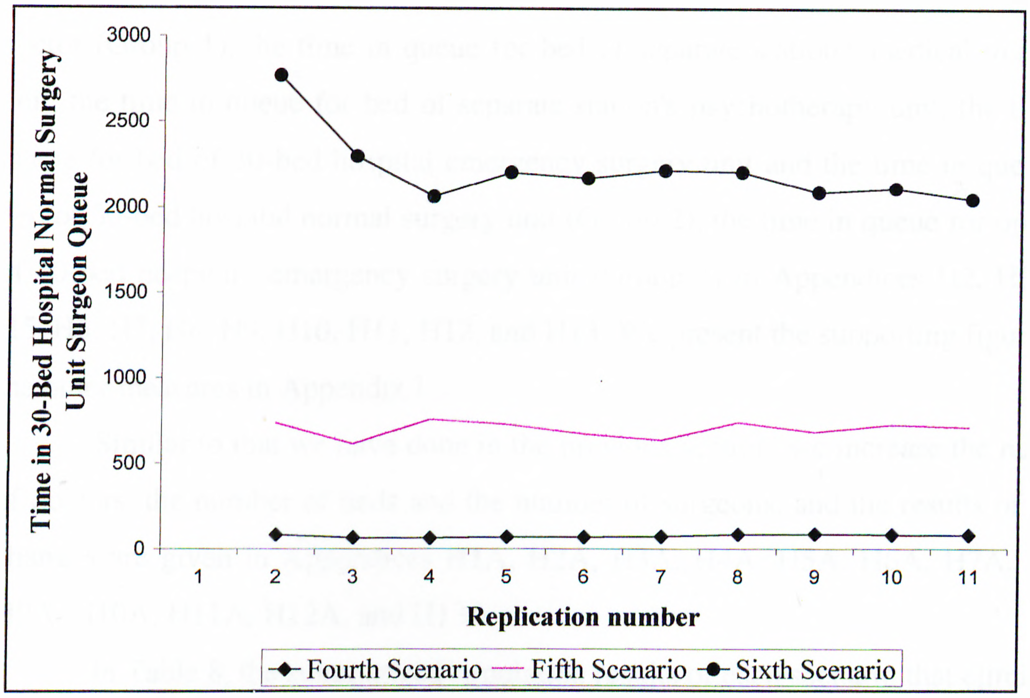


Figure 5. Time in Queue for Surgeon of Brigade 30-Bed Hospital Surgery Unit

After this change, as can be seen from Appendix H6A, the average waiting time in queue for surgeon of 30-bed hospital normal surgery unit reduced to about 16 minutes and 31 minutes for Scenario 5 and Scenario 6, respectively. Moreover, the average number of patient waiting in queue is now almost zeroing for both scenarios (Appendix H13A). This result indicates that adding only 1 surgeon for Scenario 5 and 2 surgeons for Scenario 6 decreases the waiting time in queue for surgeon and number of patient waiting in the queue to their reasonable values.

5.3.4. Discussion

In the previous sections, we presented the detailed comparisons of the alternative scenarios. Because of the space limitation and similarity of the simulation result, we deliberately gave one sample from each group in the text. These were the time in queue of first battalion's doctor, the time in queue for bed of separate station's surgery unit and the time in queue for surgeon of 30-bed hospital's normal surgery unit. The simulation results of the other performance measures are given in Appendices. Specifically you can obtain the time in queue of second battalion's doctor (Group 1), the time in queue for bed of separate station's medical treatment unit, the time in queue for bed of separate station's psychotherapy unit, the time in queue for bed of 30-bed hospital emergency surgery unit and the time in queue for bed of 30-bed hospital normal surgery unit (Group 2), the time in queue for operator of 30-bed hospital's emergency surgery unit (Group 3) in Appendices H2, H3, H4, H5, H6, H7, H8, H9, H10, H11, H12, and H13. We present the supporting figures for the other measures in Appendix I.

Similar to that we have done in the previous section, we increase the number of doctors, the number of beds and the number of surgeons, and the results of these changes are given in Appendices H1A, H2A, H3A, H4A, H5A, H6A, H7A, H8A, H9A, H10A, H11A, H12A, and H13A.

In Table 8, the summarized simulation results of each scenario that eliminates the bottlenecks are given.

(1) Existing System				
Measures	**Existing System**	**Scenario 1**	**Scenario 2**	**Scenario 3**
Number of First Battalion's Dr.	1	1	1	2
Number of Second Battalion's Dr.	1	1	1	2
Number of Separate Station Medic. Tr. Bed	12	25	30	30
Number of Separate Station Therapy Bed	9	22	22	25
Number of Separate Station Surgery Bed	9	60	68	70
Number of 30-Bed H. Emergency Sur. Bed	15	16	25	25
Number of 30-Bed H. Normal Surgery Bed	15	24	35	35

(1) Proposed System:				
Measures	**Proposed System**	**Scenario 4**	**Scenario 5**	**Scenario 6**
Number of First Battalion's Dr.	1	1	1	2
Number of Second Battalion's Dr.	1	1	1	2
Number of Separate Station Medic. Tr. Bed	12	15	30	33
Number of Separate Station Therapy Bed	9	12	30	24
Number of Separate Station Surgery Bed	9	30	52	71
Number of 30-Bed H. Emergency Sur. Bed	15	17	28	38
Number of 30-Bed H. Normal Surgery Bed	15	21	38	53
Number of 30-Bed H. Normal Sur. Surgeon	2	2	2	3

Table 8. Simulation results of each scenario that eliminates the bottlenecks

CHAPTER 6

CONCLUSION

This study is performed to model and analyze the existing brigade casualty evacuation system and improve patient flow processes in the main facilities. The simulation model developed in this study allowed us comparisons of alternatives as well as providing a tool for evaluating the impact of alternative system designs. The purpose was also to make a comparison between the existing system and the new proposed system to find the best one. The third objective was to propose some new alternative systems to solve the problems associated with these systems.

This study also presents simulation modelling as a decision support technique. Specifically for the first time, we developed a simulation model of casualty evacuation of Brigade in defence operation in war conditions. We used Arena Simulation Software Package 3.0 for this purpose. In this study, we basically analyze two system designs in the army: one is the existing system and the other is the proposed system. These two systems have the same casualty procedure until battalion level. After battalion level the procedure is changing significantly. We compared these two systems and found that main problems occur in the brigade separate station's units and 30-bed hospital. For this reason we chose the performance measures of time in separate surgery, time in system of 30-bed hospital, and time in separate surgery bed queue from the two systems.

The results of the comparisons indicate that proposed system is better than the existing system in the terms of treatment time, time-in-system and waiting time in queue. Then we compared five alternatives and we have selected the best of five alternative systems. The first alternative is the existing system. The second alternative is the proposed new system. The difference between these two systems is that, in the proposed system the patients can be sent from battalion medical aid station to all the higher level medical facilities, but in the existing system the patient must be sent to brigade separate station after battalion medical aid station. The third alternative is the revised version of the existing system. In this system, the number of bed of separate station medical treatment section is increased from 9 to 30, number of bed of separate station therapy unit is increased from 9 to 10 and number of bed of separate station surgery section is increased from 12 to 60. The fourth alternative is the revised version of the existing system such that the number of doctor of separate station's medical treatment unit is increased from 1 to 2. The fifth alternative is the revised version of the proposed system such that the number of bed of separate station medical treatment section is increased from 9 to 15, number of bed of separate station therapy section is increased from 9 to 10 and number of bed of separate station surgery section is increased from 12 to 35. We applied "two-stage" procedure of Dudewicz and Dalal (1975) for three different performance measures, namely time in brigade separate surgery, time in system of 30-bed hospital, and time in queue for bed of brigade separate surgery unit. The results indicate that the revised proposed system has the smallest weighted sample means. The main problem of the system is the number of bed's being insufficient. When we increase the number of the beds, time in system and waiting time decrease. We can also observe that we have increased the number of the beds of separate station totally from 30 to 60 for revised new system and from 30 to 100 for revised existing system. Thus, the revised proposed system is found to be the best system in terms of time-in-queue and NQ (number of patient waiting in the queue).

We also looked at the behaviour of the existing system and proposed new system under increased arrival rates. Specifically, we wanted to see if the existing system or the proposed system is working well at the more severe war conditions. To achieve this goal, we created three scenarios for the existing system and three scenarios for the proposed system. We run the simulation model of each scenario for 10 replications. We determined the bottlenecks in each scenario. Finally we made graphical comparisons of scenarios for each performance measure. We determined the measures of bottlenecks and separated them into three groups. First group is the time-in-queue for doctors of first and second battalions, second group is the time-in-queue for surgeon of 30-bed hospital's normal surgery unit and the time-in-queue for surgeon of 30-bed hospital's emergency surgery unit, third group is the time-in-queue for bed of separate station's medical treatment unit, the time-in-queue for bed of separate station's psychotherapy unit, the time-in-queue for bed of separate station's surgery unit, the time-in-queue for bed of 30-bed hospital emergency surgery unit and the time-in-queue for bed of 30-bed hospital normal surgery unit. After running the simulation model of each scenario for 10 replications, we observe that especially in the third scenario and sixth scenario, there is a need to increase number of first and second battalion's doctor, number of brigade 30-bed hospital normal surgery unit surgeon, number of separate station's unit's bed and number of 30-bed hospital surgery unit's bed.

We create totally 17 alternative simulation models in this study: We performed two simulation experiments for the comparison of the existing system and the new proposed system for 10 replications of about 15 minutes run length. We create five simulation models (two of them are the existing system and the new proposed system) for the comparison of five alternatives. We run the simulation model of each alternative system for 20 replications of about 12 minutes run length for stage 1 and for additional 10 replications of about 18 minutes run length for stage 2. We create 6 scenarios to see the behaviour of the system under increased arrival rates, and 6 scenarios to solve the problems that are observed after analyzing the first 6 scenarios. We run the simulation model of each scenario for 10 replications of about 12 minutes run length. The average run length is approximately 6 hours in total.

The result of our study can be summarized as follows:

1. The performance of the new proposed system is better than the existing system in terms of treatment time, time in system and waiting time in health unit's queues. But this improvement is not quite satisfactory under the increased arrival rates.

2. There is no significant improvement by the proposed system (over of the existing system) at the battalion level.

3. The main problem of both the existing system and the proposed system is the number of bed's being insufficient.

4. When we compare five alternative system designs, we observe that the revised version of the proposed system is the best among all alternative systems where the number of bed of separate station medical treatment section is increased from 9 to 15, number of bed of psychotherapy unit is increased from 9 to 10 and number of bed of surgery unit is increased from 12 to 35 (fifth alternative) is the best system among five alternatives.

5. When we analyze the alternatives under the heavy demand (increased arrival rate), we observe that there is no significant difference between the first scenario (the existing system) and the second scenario (when the existing system under 2 times increased arrival rate), and between the fourth scenario (the proposed new system) and the fifth scenario (the proposed new system under two times increased arrival rate). When we increase arrival rate by three times (third scenario and sixth scenario), we need to increase number of doctor of first and second battalion, number of bed of separate station units and 30-bed hospital units, and number of surgeon of 30-bed hospital units of both the existing and the proposed system.

6. Under increased arrival rate, the new proposed system is better than the existing system in terms of waiting time in queue, place demand for additional bed and required number of bed. Because the proposed new system requires fewer number of bed than the existing system.

7. When we increase the number of doctors, the number of bed, and the number of surgeons (as explained in Chapter 5), the proposed new system work well without need to any change in the system design.

Finally, we develop a simulation model of casualty evacuation of brigade in defence operation in Turkish Army for the first time. This simulation model can be improved with more realistic data and with support of army. We can also apply this simulation model to other type of operations (such that assault, retrograde operation and the other types of defence operation) with little changes in simulation model. This simulation model will allow commanders to see the problems that may appear during the war beforehand and to take the precautions on time. In Turkish army there are many areas such that oil supply system, big depot systems, factories, food service system, army stationary hospital, rehabilitation center, ammunition supply system, and some service systems that can be modelled via simulation. Simulation is the cheapest and the most powerful tool that can give the needed support to such complex systems' analysis. To compete against opponent forces, we need well-organized and well performing forces. To train and organize such a troop we must have expensive war games and exercises. Using simulation in analyzing these systems and in training the troops will allow us to have well-trained and well-organized units.

BIBLIOGRAPHY

Banks, J., J. S. Carson, II and B. L. Nelson [1995], Discrete-Event System Simulation, Second Edition, Prentice Hall. New Jersey.

Banks, J., [1998], Handbook of Simulation, John Wiley and Sons, New York.

Cahill, W., and M. Render [1999], "Dynamic Simulation Modelling of ICU Bed Availability", Proceedings of the 1999 Winter Simulation Conference, Arizona, pp. 1573-1576.

Dudewicz, E. J., and S. R. Dalal [1975], "Allocation of Observations in Ranking and Selection with Unequal Variances", Sankhya: The Indian Journal of Statistics, Volume 37, Series B, Pt. 1,pp. 28-78.

FM 8-10., [1991], Health Service and Support In Theater of Operations, Field Manual, Headquarter Department of Army, Washinton, DC,

FM-8-10-1., [1994], The Medical Company Tactics, Techniques, and Procedures, Field Manual, Headquarter Department of Army, Washinton, DC,

FM 8-10-6., [2000], Medical Evacuation In a Theater of Operations, Field Manual, Headquarter Department of Army, Washinton, DC.

FM 8-10-15., [1997], Employment of the Field and General Hospitals Tactics, Techniques, and Procedures, Field Manual, Headquarter Department of Army, Washinton, DC.

FM 8-55., [1994], Planning For Health Service Support, Field Manual, Headquarter Department of Army, Washinton, DC.

FM 7-8., [1992], Infantry Rifle Platoon and Squad, Field Manual, Headquarter Department of Army, Washinton, DC.

FM 7-10., [1990], The Infantry Rifle Company, Field Manual, Headquarter Department of Army, Washinton, DC.

FM 7-20., [1992], The Infantry Battalion, Field Manual, Headquarter Department of Army, Washinton, DC.

FM 7-30., [1995], The Infantry Brigade, Field Manual, Headquarter Department of Army, Washinton, DC.

FM 71-2., [1998], The Tank and Mechanized Infantry Battalion Task Force, Field Manual, Headquarter Department of Army, Washinton, DC.

Goldsman, D., and B. L. Nelson [1994], "Ranking, Selection and Multiple Comparisons in Computer Simulation", Proceedings of the 1998 Winter Simulation Conference, Washington, DC.

Goldsman, D. [1986], "Tutorial on Indifference-Zone Normal Means Ranking and Selection "Procedures, Proceedings of the 1986 Winter Simulation Conference, Washington, DC.

Iskander, W. H. [1989], "Simulation Modeling For Emergency Medical Service", Proceedings of the 1989 Winter Simulation Conference, Washington DC, pp. 1107-1111.

Kelton, W. D., R. P. Sadowski and D. A. Sadowski [1998], Simulation with Arena, McGraw-Hill, New Jersey.

Köse, Maj. A. [2000], Experiences for Face Validity, Instructor in the School of Health Service and Support, Samsun.

Kumar, A. P., and R. Kapur [1989], "Discrete Simulation Application-Scheduling Staff for the Emergency Room", Proceedings of the 1989 Winter Simulation Conference, Washington DC, pp. 1112-1120.

Law, A. M., and W. D. Kelton [1991], Simulation Modelling and Analysis, 2nd ed., McGraw-Hill, New York.

Lowery, J. C. [1992], "Simuation of a Hospital's Surgical Suite and Critical Care Area", Proceedings of the 1992 Winter Simulation Conference, Arlington, VA, pp.1071-1078.

Lowery, J. C., and J. A. Davis [1999], "Determination of Operating Room Requirements Using Simulation", Proceedings of the 1999 Winter Simulation Conference, Arizona, pp. 1568-1572.

McGuire, F. [1994], "Using Simulation to Reduce Length of Stay in Emergency Departments", Proceedings of the 1994Winter Simulation Conference, Orlando, FL, pp.861-867.

Özer, Cpt. M [2000], "Sağlik Hizmet Destek Planlaması Genel Esasları", Silahlı Kuvvatler Dergisi, Nisan 1999, Sayı: 360, pp. 47-58,

Pegden, C. D., R. E. Shannon and R. P. Sadowski [1990], Introduction to Simulation Using Siman, McGraw-Hill, New Jersey.

Sabuncuoglu, I. [2000], Lecture Notes and Handouts, Bilkent, Ankara.

Standridge, C. R. [1999], "A Tutorial on Simulation in Health Care: Applications and Issues", Proceedings of the 1999 Winter Simulation Conference, Arizona, pp. 49-55.

Sepúlveda, J. A., W. J. Thompson, F.F. Baesler and M. I. Alvarez [1999], "The Use of Simulation for Process Improvement In a Cancer Treatment Center", Proceedings of the 1999 Winter Simulation Conference, Arzona, pp. 1541-1548.

Sundstrom, S. C., C. G. Blood and S. A. Metheny [1996], "The Optimal Placement of Casualty Evacuation Assets: A Linear Programming Model", Naval Health Research Center, San Diego, USA.

Wears, R. L., and C. N. Winton [1993], "Simulation modeling of Prehospital Trauma Care", Proceedings of the 1993 Winter Simulation Conference, Los Angeles, CA, pp. 1216-1224.

APPENDICES

APPENDIX A: TABLEAU OF INJURY AND ILLNESS CATEGORY AND TREATMENT TIME ANALYSIS

PATIENT INSPECTION DATA ANALYSES								
NO	ILLNESS TYPE	INSPECT TIME (minute)						DISTRIBUTION
		DR 1	DR 2	DR 3	DR 4	DR 5	DR 6	
A	Category 2							TRIA(0.5,5,14.5)
1	Influenza	1	3	5	1	3	10	
2	Cholera	1	3	5	3	5	10	
3	Typhus	3	5	10	4	6	9	
4	Tetanouse	2	5	10	6	10	14	
5	Hepatitis	1	2	10	6	10	14	
6	First degree burn	2	5	10	1	4	4	
7	Crush	2	5	8	3	5	9	
B	Category 3							TRIA(1.5,10,15.5)
1	Dislocation	2	5	8	3	5	8	
2	Extremity fracture	3	6	10	4	6	10	
3	Arm fractura	4	7	10	3	5	15	
4	Foot Fracture	4	7	10	3	5	10	
5	Lumbar fracture	5	8	11	6	8	15	
6	Second Degree Burn	2	3	10	2	5	10	
C	Category 4							TRIA(0.5,10,30.5)
1	Bullet wound	2	6	15	1	5	10	
2	Gun Shot Wound	7	10	30	1	5	10	
3	Sharapnel Wound	7	10	30	1	5	10	
4	Leg and Foot Injury	1	3	5	3	8	13	
5	Open Chest Injury	1	5	15	3	8	15	
6	Internal Organ Injury	5	15	30	10	12	18	
7	Skull Injury	1	10	15	10	15	20	
8	Facial Injury	5	10	15	8	10	18	
9	Internal Bleeding	5	10	30	15	18	30	
10	Contagious Diseases	10	15	30	16	8	12	
11	Third Degree Injury	3	3	10	2	5	10	
D	PHYSCOLOGICAL							TRIA(4.5,20,60.5)
1	Minimal care	5	20	60	10	20	55	
2	Intermediate	5	25	20	15	20	60	
3	Intensive	10	15	60	20	20	30	
E	SURGERY							
1	Resuscitative Surgery	15	18	20	20	25	60	TRIA(14.5,20,60.5)
2	Emergency Surgery	20	30	30	25	40	90	TRIA(19.5,30,90.5)
3	Normal Surgery	30	25	40	40	120	180	TRIA(24.5,40.180.5)
F	TESTS							
1	X-Ray Test	10	15	30	30	35	45	TRIA(14.5,30,45.5)
2	Lab Test	5	5	10	10	10	15	TRIA(4.5,10,15.5)
G	NBC Cleaning	10	20	30	15	15	15	TRIA(9.5,15,30.5)

APPENDIX B 1: TABLEAU OF INPUT DATA ANALYSIS

ESTIMATION OF HISTORICAL DATA SET OF MECHANIZED INFANTRY BRIGADE

ESTIMATION OF NUMBER OF CASUALTIES OF BRIGADE

The Strength of Brigade	6278

RATE OF CASUALTIES OF BATTALIONS FOR 10 DAYS

Battalion Name	Days: 1	2	3	4	5	6	7	8	9	10
First Battalion	Rate: 0,036	0,027	0,027	0,027	0,027	0,025	0,025	0,025	0,025	0,025
Second Battalion	Rate: 0,036	0,027	0,027	0,027	0,027	0,025	0,025	0,025	0,025	0,025
Third Battalion	Rate: 0,0125	0,0125	0,0125	0,0125	0,0125	0,0125	0,0125	0,0125	0,0125	0,0125

	Estimation of Number Of Casualty		Estimation of Casualties According to Their Types		
Days	Estimation	Result of Estimation	*Casualty Type*	*Estimation of Casualty*	*Result*
1st	The Strength of Brigade * 0,036 (Rate)	225	Dead	Total Number of Casualty * 18 %	303
2nd - 5th	The Strength of Brigade * 0,027 (Rate) * 4(Days)	677	Injured	Total Number of Casualty * 72 %	1213
6th - 10th	The Strength of Brigade * 0,025 (Rate) * 5 (Days)	783	Prisoner of war	Total Number of Casualty * 10 %	169
	Total	1685	Total		1685

Estimation of Number of Prisoner of War Day by Day			Total Number of Casualties After Omitting the Prisoner of War		
1st Day	Total Number of Casualty * 10 % = 225 * % 10 = 23		1st Day	225 - 23 = 202	
2nd - 5th Days	Total Number of Casualty * 10 % = 677 * % 10 = 68		2nd - 5th Days	677 - 68 = 609	
6th - 10th Days	Total Number of Casualty * 10 % = 783 * % 10 = 78		6th - 10th Days	783 - 78 = 705	

Estimation of Number of Casualties of Battalions Day by Day

Days	Rate of Strength Of Battalions	Total Rate of Casualty	Number of Casualties: First Battalion	Second Battalion	Third Battalion
1st	First Battalion / Third Battalion = 0,036/0,0125 = 2,88 Second Battalion / Third Battalion = 0,036/0,0125 = 2,88	2,88 + 2,88 + 1 = 6,76	(202 / 6,76) * 2,86 = 86	(202 / 6,76) * 2,86 = 86	(202 / 6,76) * 1 = 30
2nd - 5th	First Battalion / Third Battalion = 0,027/0,0125 = 2,16 Second Battalion / Third Battalion = 0,027/0,0125 = 2,16	2,16 + 2,16 + 1 = 5,32	(609 / 5,32) * 2,16 = 247	(608 / 5,32) * 2,16 = 247	(608 / 5,32) * 1 = 115
6th - 10th	First Battalion / Third Battalion = 0,025/0,0125 = 2 Second Battalion / Third Battalion = 0,025/0,0125 = 2	2 + 2 + 1 = 5	(705 / 5) * 2 = 282	(705 / 5) * 2 = 282	(705 / 5) * 1 = 141
	Total Number of Casualties	1516	615	615	286

APPENDIX C: SUMMARY OF EXISTING SYSTEM SIMULATION RESULTS

A. TALLY VARIABLES

APPENDIX C1: TREATMENT TIMES

Identifier	Average Time In (minute)											
Replication	Platoon 1 of Company 1	Platoon 2 of Company 1	Platoon 3 of Company 1	Platoon 4 of Company 1	Company 1 of Battalion 1	Company 2 of Battalion 1	Company 3 of Battalion 1	Battalion 1 of Brigade	Battalion 2 of Brigade	Battalion 3 of Brigade	Separate Station Surgery Unit	Separate Station Medical Treatment
1	9	9	9	9	15	15	17	31	29	29	7127.2	3930.2
2	9	9	9	9	15	16	16	33	31	36	7056.9	4445.6
3	9	9	9	9	15	16	16	33	31	38	7135.7	4522.4
4	9	9	9	9	15	16	16	33	31	37	7104.5	4734.1
5	9	9	9	9	15	16	16	33	32	37	7085.1	4741.7
6	9	9	9	9	15	16	16	33	32	37	7117.2	4560.2
7	9	9	9	9	15	17	16	33	32	36	7121	4399.3
8	9	9	9	9	15	17	16	33	32	36	7108.1	4379.5
9	9	9	9	9	15	16	16	32	31	36	7082.4	4391.9
10	9	9	9	9	15	17	16	33	32	37	7032.9	4435.5
CUM. SUM	91	93	92	91	149	161	160	326	312	360	70971	44540.4
AVERAGE	9	9	9	9	15	16	16	33	31	36	7097.1	4454.04
VARIANCE	0.00429761	0.00168133	0.00317331	0.00249993	0.01999507	0.22203201	0.19193134	0.29528877	0.7529684	5.79056134	1071.63556	51595.80933
STAN. DEV	0.06555619	0.04100402	0.05633213	0.04999934	0.14140391	0.47120273	0.4380997	0.54340479	0.86773762	2.40635852	32.7358451	227.1471095
CONF. INT	0.04063134	0.02541405	0.03491433	0.0309893	0.08764131	0.29204868	0.27153161	0.33679909	0.53781861	1.49144685	20.2894841	140.7844416

Identifier	Average Time In (minute)											
Replication	Separate Station Therapy Unit	Separate Station Medical T. Bed	Separate Station Therapy U. Bed	Separate Station Surgery U. Bed	30 Bed Hospital Emergency Surgery U.	30 Bed Hospital Normal Surgery U.	30 Bed H. Emergency Surgery U. Bed	30 Bed H. Normal Surgery U. Bed	600 Bed Stationary Hospital	Army Stationary Hospital	Civilian Stationary Hospital	Rehabilitation Center
1	2942.8	2731.8	2733.4	2908.6	2697.6	3098.8	1276.5	2976.4	6999.6	7606	6959.9	--
2	3991.4	2783.9	2823.8	2889.7	2736.6	2977.3	1218.3	2873.3	7019.3	7638.3	6409.3	--
3	4272.6	2793.6	2836	2906.1	2757.7	2955.8	1198.7	2846.2	7000.2	7712.6	6908.2	--
4	4532.4	2837.5	2799.9	2893.9	2850.4	3029	1169	2919.7	6996.1	7554.7	6448.3	--
5	4481.1	2868	2824.1	2914.8	2910.1	2935.5	1212.9	2815.7	6994.7	7277.1	6357.3	--
6	4540	2835.6	2811.6	2898	2909.9	2973.2	1,190	2852.6	6989.8	7281.8	6105.5	--
7	4548.2	2838.8	2821.5	2926.4	2877	2975.7	1174.8	2852.7	6977.7	7294.8	6105.5	--
8	4489.3	2839.2	2820.3	2914.1	2903.2	2989.1	1168.1	2866.3	6969.4	7426.8	6115.8	--
9	4557.3	2834.6	2831.3	2901.6	2874.3	2995.5	1177.6	2872.3	6963.8	7398.8	5957.6	--
10	4556.2	2823	2836.4	2899.5	2828.9	2984.4	1177	2861	6960.2	7467.7	6007.1	--
CUM. SUM	42911.3	28186	28138.3	29052.7	28345.7	29914.3	11983.1	28736.2	69870.8	74658.6	63374.5	
AVERAGE	4291.13	2818.6	2813.83	2905.27	2634.57	2991.43	1198.31	2873.62	6987.08	7465.86	6337.45	
VARIANCE	256764.025	1506.40667	919.964556	122.040111	6002.09789	2020.92456	1021.23656	1987.53956	353.210667	24771.556	126799.023	
STAN. DEV	506.718881	38.812455	30.3309175	11.0471766	77.4732076	44.9546945	31.956792	44.5818299	18.7938997	157.389822	356.088504	
CONF. INT	314.06138	24.0557312	18.7989241	6.84697505	48.0174381	27.8626551	19.8066316	27.6315558	11.6483484	97.5492852	220.701559	

APPENDIX C2: TIME IN SYSTEM

Identifier	Average Time In System (minute)							
Replication	Company 1 of Battalion 1	Company 2 of Battalion 1	Company 3 of Battalion 1	Battalion 1 of Brigade	Battalion 2 of Brigade	Battalion 3 of Brigade	Separate Station Surgery Unit	Separate Station Medical Treatment
1	24	24	26	50	48	48	7172.1	3973.4
2	24	25	25	52	50	54	7112.8	4495.5
3	24	25	25	52	50	57	7190.7	4573.8
4	24	25	25	51	50	56	7157.2	4786.6
5	24	25	25	52	51	56	7139.2	4794.4
6	24	26	25	51	50	56	7171.1	4613.1
7	24	26	25	52	51	55	7174.3	4451.5
8	24	26	25	51	50	55	7161.5	4431.6
9	24	26	25	51	50	55	7135.1	4443.5
10	24	26	24.9265	51	50	55	7085.6	4487.2
CUM. SUM	**241**	**254**	**251**	**512**	**501**	**546**	**71499.6**	**45050.6**
AVERAGE	**24**	**25**	**25**	**51**	**50**	**55**	**7149.96**	**4505.06**
VARIANCE	**0.0194896**	**0.270090711**	**0.228497447**	**0.3270241**	**0.656608456**	**5.901268444**	**1026.058222**	**52723.07156**
STAN. DEV	**0.139605157**	**0.519702522**	**0.478014066**	**0.57186021**	**0.810313801**	**2.429252651**	**32.03214358**	**229.6150508**
CONF. INT	**0.086526455**	**0.322108564**	**0.296270305**	**0.354435593**	**0.502227725**	**1.505636496**	**19.85333407**	**142.3140571**

Identifier	Average Time In System (minute)							
Replication	Separate Station Therapy Unit	Brigade 30 Bed Hospital	600 Bed Stationary Hospital	Army Stationary Hospital	Civilian Stationary Hospital	Rehabilitation Center	Time in System of Return to Duty	Time in System of Dead
1	2986.4	9776.3	7417.8	11544	13576	-- --	359.56	396.02
2	4040.9	9173.2	7462.9	11627	13115	-- --	402.82	423.27
3	4320.3	9226	7475.1	11530	13350	-- --	410.83	433.28
4	4578	9202.9	7473.4	11518	12964	-- --	415.15	401.41
5	4529.1	9008	7482.6	11487	12745	-- --	403.09	419.75
6	4587.8	8977.4	7482.7	11455	12522	-- --	416.22	421.93
7	4596.1	8998.8	7477.6	11550	12522	-- --	415.46	411.49
8	4536.8	9016.8	7455.9	11637	12635	-- --	428.21	417.34
9	4604.7	9046.4	7443.5	11683	12621	-- --	433.6	418.89
10	4605	9019.9	7442.7	11701	12556	-- --	433.88	418.24
CUM. SUM	**43385.1**	**91445.7**	**74614.2**	**115732**	**128606**	-- --	**4118.82**	**4161.62**
AVERAGE	**4338.51**	**9144.57**	**7461.42**	**11573.2**	**12860.6**	-- --	**411.882**	**416.162**
VARIANCE	**257830.6499**	**57698.54456**	**455.6462222**	**7006.622222**	**141163.1556**	-- --	**462.51164**	**116.4433511**
STAN. DEV	**507.7702728**	**240.2052134**	**21.34587132**	**83.70556865**	**375.7168556**	-- --	**21.50608379**	**10.79089204**
CONF. INT	**314.7130266**	**148.8777776**	**13.23004541**	**51.8802188**	**232.8670958**	-- --	**13.32934416**	**6.68813138**

APPENDIX C3: SUMMARY OF APPENDIX C1 AND APPENDIX C2

AVERAGE TREATMENT TIMES (minute)				AVERAGE TIME IN SYSTEM (minute)	
Units	**Time In**	**Units**	**Time In**	**Units**	**Time In System**
Platoon 1 of Company 1	9	**Brigade Separate Station's Psycotherapy Unit**	4291.13	**Company 1 of Battalion 1**	24
Platoon 2 of Company 1	9	**Brigade Separate Station's Medical Treatment Unit Bed**	2818.6	**Battalion 1 of Brigade**	51
Platoon 3 of Company 1	9	**Brigade Separate Station's Psycotherapy Unit Bed**	2813.83	**Battalion 3 of Brigade**	55
Platoon 4 of Company 1	9	**Brigade Separate Station's Surgery Unit Bed**	2905.27	**Brigade Separate Station's Surgery Unit**	7149.96
Company 1 of of Battalion 1	15	**Brigade 30 Bed Hospital's Emergency Surgery Unit**	2834.57	**Brigade Separate Station's Medical Treatment Unit**	4505.06
Company 2 of of Battalion 1	16	**Brigade 30 Bed Hospital's Normal Surgery Unit**	2991.43	**Brigade Separate Station's Psycotherapy Unit**	4338.51
Company 3 of of Battalion 1	16	**Brigade 30 Bed Hospital's Emergency Surgery Unit Bed**	1198.31	**Brigade 30 Bed Hospital**	9144.57
Battalion 1 of Brigade	33	**Brigade 30 Bed Hospital's Normal Surgery Unit Bed**	2873.62	**600 Bed Stationary Hospital**	7461.42
Battalion 2 of Brigade	31	**600 Bed Stationary Hospital**	6987.08	**Army Stationary Hospital**	11573.2
Battalion 3 of Brigade	36	**Army Stationary Hospital**	7465.86	**Civilian Stationary Hospital**	12860.6
Brigade Separate Station's Surgery Unit	7097.1	**Civilian Stationary Hospital**	6337.45	**Time In System of Returning to Duty**	411.882
Brigade Separate Station's Medical Treatment Unit	4454.04	**Rehabilitation Center**	....	**Time In System of Dead**	416.162

APPENDIX C4: TIME IN QUEUE

Identifier	Average Time In Queue (minute)								
Replication	Platoon 1 Queue of Company 1	Company 1 Queue of Battalion 1	Company 2 Queue of Battalion 1	Company 3 Queue of Battalion 1	First Battalion Doctor Queue	Second Battalion Doctor Queue	Third Battalion Doctor Queue	Separate Station's Medical Treatment Doctor Queue	Separate Station's Therapist Queue
1	0	0.09835	0.8285	1	10	6	8	2	0.13125
2	0	0.0562	1	1	11	8	13	2	0.39053
3	0	0.03974	1	1	11	8	15	2	0.35868
4	0	0.06036	1	1	10	9	14	2	0.37016
5	0	0.05	1	1	11	9	14	2	0.43885
6	0	0.05403	1	1	11	9	14	2	0.43986
7	0	0.06873	1	0.95619	11	9	14	2	0.46092
8	0	0.05828	1	1	11	9	14	2	0.45779
9	0	0.06347	1	1	10	9	14	2	0.4437
10	0	0.08503	1	1	10	9	14	2	0.47623
CUM. SUM	0	0.64419	12.7585	11	106	86	136	22	3.96797
AVERAGE	0	0.064419	1.27585	1	11	9	14	2	0.396797
VARIANCE	0	0.000291049	0.035160998	0.013679547	0.207821803	0.783045598	3.593025847	0.003474041	0.010297911
STAN. DEV	0	0.017060149	0.187512662	0.116959598	0.455874767	0.884898637	1.895527855	0.058940992	0.101478621
CONF. INT	0	0.01057378	0.116219244	0.07249087	0.282548497	0.548454967	1.174837008	0.03653128	0.062895852

Identifier	Average Time In Queue (minute)								
Replication	Separate Station's Surgeon Queue	30 Bed H. Emergency Surgery Unit's Surgeon Queue	30 Bed H. Normal Surgery Unit's Surgeon Queue	Separate St. Medical Treatment Bed Queue	Separate Station's Psycotherapy Unit Bed Queue	Separate Station's Surgery Unit Bed Queue	30 Bed H. Emergency Surgery Unit Bed Queue	30 Bed Hospital Normal Surgery Unit Bed Queue	
1	0.58067	0	2	1442.3	95	5284.2	0	0	
2	0.41875	3	0.98544	2023.6	1365.7	5194.3	0	0	
3	0.45141	2	1	2083.2	1697.4	5245.9	0	0	
4	0.61396	1	3	2270.2	2034.6	5222.9	0	0	
5	0.78217	1	3	2224.4	1990.9	5210.3	0	0	
6	0.92617	1	3	2035.9	2065.7	5261.9	0	0	
7	0.81509	1	5	1836.5	2048.1	5250.5	0	0	
8	0.83017	1	5	1835.2	1982.3	5248.6	0	0	
9	0.79511	1	4	1881.5	2012.4	5227	0	0	
10	0.77462	1	4	1944.8	2016.1	5179.9	0	0	
CUM. SUM	6.98812	13.5074	31	19577.6	17,309	52325.5	0	0	
AVERAGE	0.698812	1.35074	3	1957.76	1,731	5232.55	0	0	
VARIANCE	0.029470638	0.469923518	1.886842464	55144.34489	378380.6098	1015.693889	0	0	
STAN. DEV	0.171670142	0.685509678	1.373623844	234.8283307	615.126499	31.86995276	0	0	
CONF. INT	0.106400144	0.424874864	0.851363974	145.5452173	381.2517838	19.75280915	0	0	

B. DISCRETE CHANGE VARIABLES (DSTATS)

APPENDIX C5: AVERAGE NUMBER OF PATIENT (To be continued)

Identifier	Number of Patient in Platoon1				Number of Patient in Company1				Number of Patient in Battalion1				Number of Patient in Battalion2			
Replication	Enter	Dutty	Dead	In System	Enter	Dutty	Dead	In System	Enter	Dutty	Dead	In System	Enter	Dutty	Dead	In System
1	29	7	4	17	20	5	0.76534	14	238.32	79	30	129.63	238.91	82	33	124.44
2	33	12	4	18	19	3	2	14	244.64	85	33	127.42	247.7	84	37	127.57
3	34	11	4	19	17	3	2	13	237.36	79	33	126.11	242.04	81	36	125.58
4	33	11	5	18	18	3	1	14	235.54	79	34	123.46	247.13	84	36	127.49
5	32	11	4	17	17	3	1	14	237.52	79	34	125.21	246.76	83	36	128.15
6	32	10	4	17	17	3	1	13	236.67	78	35	124.08	243.94	83	34	127.72
7	31	10	4	17	17	3	1	13	237.66	78	35	125.22	241.08	82	33	125.92
8	30	9	4	17	18	4	0.94857	13	237.2	78	34	125.45	240.15	81	34	125.95
9	29	9	5	17	17	4	0.84317	13	238.63	77	34	127.22	237.55	80	33	125.13
10	29	9	4	17	17	4	0.75885	13	238.03	76	35	127.26	238.35	80	34	125.45
CUM. SUM	**313**	**100**	**43**	**174**	**178**	**35**	**11.20853**	**134**	**2381.57**	**789**	**336**	**1261.06**	**2423.61**	**820**	**345**	**1263.4**
AVERAGE	**31**	**10**	**4**	**17**	**18**	**3**	**1.120853**	**13**	**238.157**	**79**	**34**	**126.106**	**242.361**	**82**	**35**	**126.34**
VARIANCE	**3.1459299**	**1.9927762**	**0.0438962**	**0.3769053**	**0.8724965**	**0.5892178**	**0.0851354**	**0.1872079**	**5.9510456**	**5.5960546**	**2.6349986**	**3.3157822**	**14.540943**	**2.8254833**	**1.9709478**	**1.6431333**
STAN. DEV	**1.7736769**	**1.4116572**	**0.2095142**	**0.6139261**	**0.9340752**	**0.7676053**	**0.2917797**	**0.4326753**	**2.4394765**	**2.3655982**	**1.6232679**	**1.8209289**	**3.8132589**	**1.6809174**	**1.4039045**	**1.2818476**
CONF. INT	**1.0993145**	**0.8749368**	**0.1298556**	**0.3805078**	**0.5789343**	**0.4757572**	**0.1808433**	**0.2681696**	**1.5119732**	**1.4661838**	**1.0060919**	**1.128601**	**2.3634354**	**1.0418227**	**0.8701317**	**0.7944816**

Identifier	Number of Patient in Battalion3				Number of Patient in Brigade Separate Station (Total)				Number of Patient in Brigade Separate Station's Medical Treatment				Number of Patient in Brigade Separate Station's Psycotherapy Unit			
Replication	Enter	Dutty	Dead	In System	Enter	Dutty	Dead	In System	Enter	Dutty	Dead	In System	Enter	Dutty	Dead	In System
1	102.28	36	11	56	416.92	6	3	408.29	170.25	0.77865	2	167.13	107.35	1	0.0761	106.33
2	117.24	41	18	59	411.53	5	3	403.05	166.99	3	1	162.53	112.21	0.47909	0.03807	111.7
3	121.61	42	19	61	406.3	5	4	397.55	162.95	2	2	159.21	115.08	0.74352	0.31764	114.03
4	115.63	39	18	60	406.61	5	4	397.57	164.4	2	2	160.56	114.84	1	0.23823	113.41
5	119.66	41	18	61	409.51	5	4	400.63	162.34	2	2	158.53	118.02	1	0.20007	116.66
6	118.41	40	18	61	409.97	5	3	401.73	161.82	2	1	158.23	117.52	0.97252	0.23429	116.32
7	115.82	39	18	60	409.35	5	3	401.24	159.77	2	1	158.29	118.74	1	0.26709	117.46
8	115.78	39	17	60	409	5	3	401.14	161.57	2	1	158.29	117.72	1	0.2337	116.37
9	116.01	39	18	60	408.76	5	3	400.51	161.3	2	1	157.96	117.74	1	0.20773	116.36
10	115.97	39	17	60	409.55	5	3	401.01	162.92	2	1	159.33	116.84	1	0.18696	115.52
CUM. SUM	**1056.13**	**395**	**171**	**598**	**4097.5**	**51**	**34**	**4012.72**	**1634.31**	**21.99155**	**15**	**1600.06**	**1156.06**	**10**	**1.99988**	**1144.16**
AVERAGE	**117.34778**	**39**	**17**	**60**	**410**	**5**	**3**	**401.272**	**163.431**	**2.199155**	**1**	**160.006**	**115.606**	**1**	**0.199988**	**114.416**
VARIANCE	**4.5104444**	**2.8904668**	**5.4257102**	**2.1884691**	**8.6875556**	**0.1172901**	**0.1039809**	**9.02904**	**9.5321878**	**0.3486846**	**0.1269181**	**8.2141822**	**12.268471**	**0.053459**	**0.0071017**	**11.184[illegible]71**
STAN. DEV	**2.1237807**	**1.7001373**	**2.3293154**	**1.4793475**	**2.947466**	**0.3424764**	**0.3224607**	**3.0048361**	**3.0874241**	**0.5904952**	**0.3562556**	**2.8660395**	**3.5026377**	**0.2312121**	**0.0842718**	**3.344379**
CONF. INT	**1.3163068**	**1.0537351**	**1.443696**	**0.9168909**	**1.8268221**	**0.2122649**	**0.1998593**	**1.8623797**	**1.9135673**	**0.3659855**	**0.2208051**	**1.7763544**	**2.1709143**	**0.1433039**	**0.0522312**	**2.0728264**

APPENDIX C5: AVERAGE NUMBER OF PATIENT

Identifier	Number of Patient In Brigade Separate Station's Surgery Unit				Number of Patient In 30 Bed Hospital Emergency Surgery Unit				Number of Patient In 30 Bed Hospital Normal Surgery Unit				Number of Patient In Brigade 30 Bed Hospital (Total)			
Replication	Enter	Dutty	Dead	In System	Enter	Dutty	Dead	In System	Enter	Dutty	Dead	In System	Enter	Dutty	Dead	In System
1	131.39	3	2	126.93	6	0	0.43712	5	5	0	0.89194	4	10	0	0.83089	10
2	124.98	2	2	121.51	6	0	1	5	6	0.24729	0.19689	5	12	0.24729	2	10
3	121.14	2	2	117.22	5	0	1	4	5	0.16486	0.244	5	11	0.16486	2	9
4	120.3	2	2	116.57	5	0	1	4	6	0.21322	0.24963	6	11	0.21322	1	10
5	121.85	2	2	118.17	5	0	1	4	7	0.17057	0.35278	6	11	0.17057	1	10
6	123.29	2	2	119.87	5	0	1	4	7	0.14214	0.49963	6	11	0.14214	2	11
7	123.56	1	2	120.44	5	0	1	4	7	0.12184	0.44104	7	11	0.12184	2	11
8	122.5	1	2	119.3	5	0	1	4	7	0.14154	0.41818	7	11	0.15385	1	11
9	122.49	2	2	119	5	0	1	4	7	0.1903	0.46255	7	11	0.20124	2	11
10	122.43	2	2	118.84	5	0	1	4	7	0.21166	0.5281	6	11	0.22151	2	10
CUM. SUM	1233.93	17	19	1197.85	51	0	11.12542	42	64	1.60342	4.28474	60	108	1.63652	14.91199	102
AVERAGE	123.393	2	2	119.785	5	0	1.112542	4	6	0.160342	0.428474	6	11	0.163652	1.491199	10
VARIANCE	9.563646	0.100762	0.01961	8.414561	0.202667	0	0.074167	0.223388	0.819159	0.004654	0.039621	0.686586	0.185485	0.004817	0.067891	0.323658
STAN. DEV	3.092514	0.31743	0.140034	2.900786	0.450186	0	0.272337	0.47264	0.905074	0.068223	0.199051	0.828605	0.43068	0.069403	0.260559	0.56891
CONF. INT	1.916722	0.196741	0.086792	1.79789	0.279022	0	0.168793	0.292939	0.56096	0.042284	0.12337	0.513564	0.266933	0.043016	0.161493	0.352607

Identifier	Number of Patient In 600 Bed Hospital				Number of Patient In Army Hospital				Number of Patient In Civilian Hospital				Number of Patient In Rehabilitation C.			
Replication	Enter	Dutty	Dead	In System	Enter	Dutty	Dead	In System	Enter	Dutty	Dead	In System	Enter	Dutty	Dead	In System
1	230.13	5	3	222.14	58	0.50387	0	58	13	0	0	13	1	0	0	1
2	219.32	5	4	209.68	51	0.14265	0.05353	51	14	0	0.051	14	1	0	0	1
3	216.85	6	4	207.09	51	0.22859	0.03569	51	13	0	0.034	13	1	0	0	1
4	213.71	5	4	204.78	51	0.18402	0.02677	51	13	0.05107	0.0255	13	1	0	0	1
5	215.9	5	4	206.8	51	0.17675	0.03131	51	14	0.04086	0.0204	14	1	0	0	1
6	215.05	5	4	205.6	52	0.22185	0.02732	51	14	0.03765	0.017	14	2	0	0	2
7	216.23	5	4	206.69	52	0.19961	0.02342	51	14	0.03227	0.01457	14	2	0	0	2
8	217.28	5	4	207.69	52	0.19116	0.04983	52	14	0.02824	0.01275	14	1	0	0	1
9	216.32	5	4	206.64	52	0.19293	0.04429	52	14	0.03894	0.01133	13	1	0	0	1
10	215.92	5	4	206.52	52	0.224	0.06657	51	14	0.04031	0.0102	14	1	0	0	1
CUM. SUM	2176.71	52	42	2083.63	522	2.26543	0.35873	520	136	0.26934	0.19675	136	14	0	0	14
AVERAGE	217.671	5	4	208.363	52	0.226543	0.035873	52	14	0.026934	0.019675	14	1	0	0	1
VARIANCE	21.27068	0.08994	0.075542	25.077	4.265441	0.010153	0.000349	4.242206	0.048072	0.00038	0.000205	0.047085	0.025148	0	0	0.025148
STAN. DEV	4.612014	0.299899	0.274849	5.007694	2.065295	0.100761	0.018674	2.059662	0.219253	0.019496	0.014332	0.216991	0.158581	0	0	0.158581
CONF. INT	2.858499	0.185876	0.17035	3.103739	1.280057	0.062451	0.011574	1.276566	0.135892	0.012084	0.008883	0.13449	0.098288	0	0	0.098288

APPENDIX C6 and D6: SUMMARY OF EXISTING AND PROPOSED SYSTEM RESULTS

Identifier	EXISTING SYSTEM NUMBER OF PATIENT					PROPOSED SYSTEM Average Patient				
Replication	Number of Patient Entering In System	Number of Dead	Number of Patient Return to Duty	Number of Patient Stay In Health System	Number of Patient (Patient In Dutty + In H. System)	Number of Patient Entering In System	Number of Dead	Number of Patient Return to Duty	Number of Patient Stay In Health System	Number of Patient (Patient In Dutty + In H. System)
1	1482	296.29	694.77	490.94	1185.71	1468.9	681.99	318.85	468.06	786.91
2	1501.3	314.19	714.76	472.35	1187.11	1455.4	668.94	315.72	470.74	786.46
3	1483.2	314.15	696.7	472.31	1169.01	1452.2	665.91	321.87	464.42	786.29
4	1496	308.16	709.78	478.06	1187.84	1470.6	684.27	322.37	463.96	786.33
5	1488.1	306.09	702.06	480.95	1183.01	1464.9	678.65	320.61	465.64	786.25
6	1482.8	307.6	696.88	478.32	1175.2	1464.8	678.56	320.93	465.63	786.56
7	1481.4	309.64	695.65	476.11	1171.76	1452.5	665.98	320.72	465.8	786.52
8	1479	310.53	693.02	475.45	1168.47	1453.9	667.31	321.68	464.91	786.59
9	1477.1	311.87	691.03	473.93	1164.96	1459.1	672.66	322.19	464.25	786.44
10	1474.1	313.38	687.98	472.74	1160.72	1463.9	677.41	322.12	464.37	786.49
CUM. SUM	14845	3091.9	6982.63	4771.16	11753.79	14606.2	6741.68	3207.06	4657.78	7864.84
AVERAGE	1484.5	309.19	698.263	477.116	1175.379	1460.62	674.168	320.706	465.778	786.484
VARIANCE	71.22888889	28.43857778	69.79326778	31.89369333	98.08045444	47.36177778	47.22208444	4.182071111	4.454484445	0.035382222
STAN. DEV	8.439720901	5.332783305	8.354236517	5.647450162	9.903557666	6.881989377	6.871832685	2.045011274	2.110564959	0.188101627
CONF. INT	5.230889343	3.305227707	5.177906625	3.500256373	6.138166754	4.265416512	4.259121454	1.267485952	1.30811574	0.116584282

APPENDIX C7: NUMBER OF PATIENT IN QUEUES (NQ)

Replication	Battalion 1 Doctor Queue	Battalion 3 Doctor Queue	Separate S. Medical Treatment Dr. Queue	Separate Station Therapist Queue	Separate Station Surgeon Queue	30 Bed H. Emergency Surgeon Queue	30 Bed H. Normal Surgeon Queue	Separate S. Medical Treatment Bed Queue	Separate Station Therapist Bed Queue	Separate Station Surgery Bed Queue	30 Bed H. Normal Surgery Bed Queue	30 Bed H. Emergency Surgery Bed Queue
1	0.31137	0.1187	0.05279	0.002	0.01048	0	0.00205	8	0.50395	105.15	0	0
2	0.37308	0.20968	0.05122	0.00614	0.00718	0.00234	0.00103	14	7	99	0	0
3	0.35561	0.2444	0.04845	0.0057	0.00758	0.00156	9.65E-04	14	9	95	0	0
4	0.33375	0.2198	0.04776	0.00587	0.01028	0.00117	0.00347	16	11	95	0	0
5	0.3517	0.22671	0.04698	0.00713	0.01325	9.37E-04	0.00336	15	11	96	0	0
6	0.34337	0.22566	0.04976	0.00718	0.01583	.00109	0.00357	14	11	97	0	0
7	0.3512	0.20969	0.04736	0.0076	0.01396	.00104	0.00538	13	11	98	0	0
8	0.33997	0.21052	0.04913	0.00751	0.01409	9.13E-04	0.00547	13	11	97	0	0
9	0.33742	0.2126	0.04966	0.00724	0.0135	8.12E-04	0.00486	13	10	96	0	0
10	0.34006	0.21965	0.05168	0.00774	0.01321	8.30E-04	0.00484	14	10	96	0	0
CUM. SUM	3.43753	2.09741	0.49479	0.06411	0.11936	0.00856234	0.034995	135	90.51665	974.307	0	0
AVERAGE	0.343753	0.209741	0.049479	0.006411	0.011936	0.00107029	0.0034995	13	9.051665	97.4307	0	0
VARIANCE	0.00025958	0.00113769	3.75785E-06	2.946E-06	8.461E-06	4.5347E-07	2.8573E-06	4.2511097	10.86832233	8.82690757	0	0
STAN. DEV	0.0161114	0.03372969	0.001938519	0.0017163	0.0029088	0.0006734	0.00169035	2.06182194	3.296713868	2.9710112	0	0
CONF. INT	0.00998575	0.02090547	0.001201482	0.0010638	0.0018029	0.00041737	0.00104767	1.2779051	2.043283853	1.84141526	0	0

APPENDIX C8: UTILIZATION OF RESOURCES (NR)

Replication	Battalion 1 Doctor	Battalion 3 Doctor	Separate St. Medical Treatment Doctor	Separate Station Therapist	Separate Station Surgeon	30 Bed Hospital Emergency Surgeon	30 Bed Hospital Normal Surgeon	Separate St Medical Treatment Bed	Separate Station Psycotherapy Bed	Separate Station Surgery Bed	30 Bed H. Normal Surgery Bed	30 Bed H. Emergency Surgery Bed
1	0.3434	0.13988	0.35951	0.46034	0.59405	0.03031	0.09043	11	7	9	2	2
2	0.3452	0.15757	0.34177	0.47209	0.54547	0.04034	0.07947	11	8	9	2	2
3	0.33564	0.16002	0.33846	0.47306	0.5375	0.03781	0.07679	11	8	9	2	2
4	0.33266	0.15262	0.33908	0.47299	0.53619	0.0368	0.08698	11	8	9	3	2
5	0.33464	0.15763	0.33598	0.48517	0.54503	0.03737	0.098	11	8	9	3	2
6	0.33334	0.15941	0.33638	0.4873	0.54623	0.03986	0.10112	11	8	9	3	2
7	0.33482	0.15639	0.33343	0.49179	0.54532	0.3812	0.10194	11	8	9	3	2
8	0.3339	0.15673	0.3371	0.48987	0.54101	0.03641	0.10254	11	8	9	3	2
9	0.33635	0.15661	0.33671	0.48674	0.54125	0.03651	0.10257	11	8	9	3	2
10	0.33659	0.15606	0.33979	0.48563	0.54208	0.03698	0.09887	11	8	9	3	2
CUM. SUM	3.36654	1.55292	3.39821	4.80498	5.47413	0.71359	0.93871	113	80	88	26	18
AVERAGE	0.336654	0.155292	0.339821	0.480498	0.547413	0.071359	0.093871	11	8	9	3	2
VARIANCE	1.7956E-05	3.336E-05	5.31532E-05	0.0001042	0.0002802	0.0118593	9.6555E-05	0.00173383	0.173521072	0.00010286	0.06048033	0.00409958
STAN. DEV	0.00423748	0.00577578	0.007290622	0.0102061	0.0167395	0.10890044	0.00982624	0.04163932	0.416558605	0.01014215	0.24592749	0.06402794
CONF. INT	0.00262637	0.0035798	0.004518684	0.0063257	0.010375	0.06749585	0.00609025	0.02580781	0.258180572	0.00628605	0.15242441	0.03968414

APPENDIX D: PROPOSED SYSTEM SIMULATION RESULTS

A. TALLY VARIABLES

APPENDIX D1: TREATMENT TIMES

Identifier	Average Time in (minute)											
Replication	Platoon 1 of Company 1	Platoon 2 of Company 1	Platoon 3 of Company 1	Platoon 4 of Company 1	Company 1 of Battalion 1	Company 2 of Battalion 1	Company 3 of Battalion 1	Battalion 1 of Brigade	Battalion 2 of Brigade	Battalion 3 of Brigade	Separate Station Surgery Unit	Separate Station Medical Treatment
1	9	9	9	9	15	17	16	34	32	37	5238,7	2967,3
2	9	9	9	9	15	17	16	34	31	38	5123,6	3128,6
3	9	9	9	9	15	17	16	33	32	37	5123,7	3102
4	9	9	9	9	15	17	16	33	32	37	5191,3	3120,3
5	9	9	9	9	15	17	16	33	31	36	5069,2	3098,2
6	9	9	9	9	16	17	16	32	31	37	5128,7	3292,7
7	9	9	9	9	15	17	16	32	31	37	5122,3	3281,8
8	9	9	9	9	16	17	16	32	31	37	5067,8	3319,1
9	9	9	9	9	16	17	16	32	31	37	5076,4	3273,8
10	9	9	9	9	16	17	16	32	31	38	5046,3	3215,1
CUM. SUM	90	90	90	92	154	168	160	325	313	372	51188	31798,9
AVERAGE	9	9	9	9	15	17	16	33	31	37	5118,8	3179,89
VARIANCE	0,01733731	0,00448836	0,00192156	0,00463336	0,04809667	0,03385573	0,03247232	0,77508938	0,22859379	0,31261917	3544,97111	12962,91656
STAN. DEV	0,13167123	0,0669952	0,04383555	0,06806879	0,21930952	0,18399928	0,18020078	0,8803916	0,47811483	0,55912357	59,53966	113,8548047
CONF. INT	0,08160905	0,04152323	0,02716902	0,04218863	0,13592675	0,11404167	0,11168738	0,54566154	0,29633276	0,3465415	36,9023308	70,56653787

Identifier	Average Time in (minute)											
Replication	Separate Station Therapy Unit	Separate Station Medical T. Bed	Separate Station Therapy U. Bed	Separate Station Surgery U. Bed	30 Bed Hospital Emergency Surgery U.	30 Bed Hospital Normal Surgery U.	30 Bed H. Emergency Surgery U. Bed	30 Bed H. Normal Surgery U. Bed	600 Bed Stationary Hospital	Army Stationary Hospital	Civilian Stationary Hospital	Rehabilitation Center
1	2993,3	2852,6	2930,1	2771,5	2886,4	3679,8	1219,8	2876,5	6939,5	7615,4	8304,7	- --
2	2851,8	2866,3	2789,3	2802,2	3085,6	3642,8	1237,6	2805,6	6955,9	7831	8505,6	-- --
3	2878,6	2898,4	2810,7	2796,8	3039,1	3708,3	1229,5	2874,1	6964,3	7646	8496,9	- --
4	3007,4	2878,9	2790,3	2845,7	3036,8	3634,5	1220,8	2894,1	6970,4	7671,8	8519,1	- --
5	3011,2	2863,4	2821,9	2834,1	3032,3	3618,6	1212,2	2901,2	6993,9	7705,3	8507,8	- --
6	2997,5	2851,4	2818,1	2839,6	3001,2	3661,7	1209,4	2886,3	7004,5	7699,6	8572,1	- --
7	2991,8	2830,9	2819,3	2849,3	2998,4	3896,4	1215	2876	7013,7	7736,5	8638,5	- --
8	2995,9	2845,9	2823,8	2860,7	2994,4	3839,5	1220,6	2885,3	7022,8	7671,6	8661,9	- --
9	2996,7	2847,6	2827,4	2882	2989,8	3786,5	1221,7	2867,4	7030,7	7753,3	8671,8	- --
10	2987,2	2824,4	2822	2869,4	2978	3766,8	1210,2	2854,4	7035,3	7751,1	8414,4	- --
CUM. SUM	29711,4	28559,8	28252,9	28351,3	30042	37234,9	12196,8	28720,9	69931	77081,6	85292,8	- --
AVERAGE	2971,14	2855,98	2825,29	2835,13	3004,2	3723,49	1219,68	2872,09	6993,1	7708,16	8529,28	- --
VARIANCE	3206,92489	479,652889	1537,12767	1217,88456	2733,96222	8954,641	77,4617778	722,543222	1137,02	3886,96711	13052,2662	- --
STAN. DEV	56,6297174	21,9009792	39,2062197	34,8982028	52,2873046	94,6289649	8,80123729	26,8801641	33,7197272	62,345546	114,246515	- --
CONF. INT	35,0987655	13,574098	24,2997843	21,6297007	32,4073637	58,6504755	5,45495507	16,6601675	20,8992884	38,6414025	70,8093177	- --

APPENDIX D2: TIME IN SYSTEM

Identifier	Average Time In System (minute)							
Replication	Company 1 of Battalion 1	Company 2 of Battalion 1	Company 3 of Battalion 1	Battalion 1 of Brigade	Battalion 2 of Brigade	Battalion 3 of Brigade	Separate Station Surgery Unit	Separate Station Medical Treatment
1	24	27	26	53	51	56	5284.2	3012.8
2	24	26	25	52	49	57	5167.3	3174.3
3	24	26	25	52	50	55	5163.9	3142.2
4	25	26	25	51	50	55	5229.9	3159
5	24	26	25	51	50	54	5107	3137.6
6	25	26	25	51	50	56	5166.1	3330.9
7	25	26	25	50	50	56	5159.9	3320.4
8	25	26	25	50	50	56	5106	3357.2
9	25	26	25	50	50	56	5114.4	3310.8
10	25	26	25	50	50	57	5083.9	3252.4
CUM. SUM	**246**	**260**	**253**	**512**	**500**	**558**	**51582.6**	**32197.6**
AVERAGE	**25**	**26**	**25**	**51**	**50**	**56**	**5158.26**	**3219.76**
VARIANCE	**0.013689344**	**0.056609289**	**0.0444201**	**1.103275822**	**0.263303511**	**0.388283778**	**3775.851556**	**12453.396**
STAN. DEV	**0.117001472**	**0.237927066**	**0.210760765**	**1.050369374**	**0.513131086**	**0.623124207**	**61.44795811**	**111.5947848**
CONF. INT	**0.072516824**	**0.147465795**	**0.130628282**	**0.651012756**	**0.318035627**	**0.386208716**	**38.08508279**	**69.16579085**

Identifier	Average Time In System (minute)							
Replication	Separate Station Therapy Unit	Brigade 30 Bed Hospital	600 Bed Stationary Hospital	Army Stationary Hospital	Civilian Stationary Hospital	Rehabilitation Center	Time In System of Return to Duty	Time In System of Dead
1	3029.8	3739.3	7382	11148	9216.9	-- --	488.94	494.93
2	2889.6	3699.4	7417.4	11289	9403.2	-- --	509.69	475.93
3	2915.2	3766.9	7400.4	11366	9391	-- --	511.42	431.62
4	3042.6	3692.7	7452.3	11487	9353.3	-- --	499.33	433.89
5	3046.2	3676.6	7471.2	11483	9325.3	-- --	488.65	423.04
6	3033	3719.1	7474.9	11501	9351.4	-- --	491.98	466.6
7	3027.1	3954.1	7474.7	11454	9409.3	-- --	511.63	466.64
8	3030.1	3897.2	7481.9	11366	9430.7	-- --	510.01	453.26
9	3031	3843.8	7494.9	11376	9441.9	-- --	511.45	444.79
10	3021.8	3824.4	7507.5	11344	9415.5	12449	513.02	454.86
CUM. SUM	**30066.4**	**37813.5**	**74557.2**	**113814**	**93738.5**	12449	**5036.12**	**4545.56**
AVERAGE	**3006.64**	**3781.35**	**7455.72**	**11381.4**	**9373.85**	12449	**503.612**	**454.556**
VARIANCE	**3104.578222**	**8935.149444**	**1760.492889**	**11773.82222**	**4436.267222**	0	**105.0935956**	**491.2819378**
STAN. DEV	**55.71874211**	**94.52591943**	**41.9582279**	**108.507245**	**66.60530926**	0	**10.25151674**	**22.16488073**
CONF. INT	**34.53414843**	**58.58660854**	**26.00546271**	**67.25215185**	**41.28157868**	0	**6.353829743**	**13.73766263**

APPENDIX D3: SUMMARY OF APPENDIX D1 AND APPENDIX D2

AVERAGE TREATMENT TIMES (minute)				AVERAGE TIME IN SYSTEM (minute)	
Units	Time In	Units	Time In	Units	Time In System
Platoon 1 of Company 1	9	Brigade Separate Station's Psycotherapy Unit	3046.64	Company 1 of Battalion 1	25
Platoon 2 of Company 1	9	Brigade Separate Station's Medical Treatment Unit Bed	2909.06	Battalion 1 of Brigade	49
Platoon 3 of Company 1	9	Brigade Separate Station's Psycotherapy Unit Bed	2912.21	Battalion 3 of Brigade	58
Platoon 4 of Company 1	9	Brigade Separate Station's Surgery Unit Bed	2833.16	Brigade Separate Station's Surgery Unit	5612.41
Company 1 of of Battalion 1	15	Brigade 30 Bed Hospital's Emergency Surgery Unit	2951.11	Brigade Separate Station's Medical Treatment Unit	3173.5
Company 2 of of Battalion 1	17	Brigade 30 Bed Hospital's Normal Surgery Unit	3632.76	Brigade Separate Station's Psycotherapy Unit	3081.91
Company 3 of of Battalion 1	17	Brigade 30 Bed Hospital's Emergency Surgery Unit Bed	1208.65	Brigade 30 Bed Hospital	3689.33
Battalion 1 of Brigade	31	Brigade 30 Bed Hospital's Normal Surgery Unit Bed	2864.28	600 Bed Stationary Hospital	7430.29
Battalion 2 of Brigade	30	600 Bed Stationary Hospital	6971.07	Army Stationary Hospital	11448.1
Battalion 3 of Brigade	39	Army Stationary Hospital	7765.21	Civilian Stationary Hospital	8890.78
Brigade Separate Station's Surgery Unit	5574.47	Civilian Stationary Hospital	8293.47	Time In System of Returning to Duty	534.554
Brigade Separate Station's Medical Treatment Unit	3136.5	Rehabilitation Center	- --	Time In System of Dead	493.219

APPENDIX D4: TIME IN QUEUE

Identifier	Average Time In Queue (minute)								
Replication	Platoon 1 Queue of Company 1	Company 1 Queue of Battalion 1	Company 2 Queue of Battalion 1	Company 3 Queue of Battalion 1	First Battalion Doctor Queue	Second Battalion Doctor Queue	Third Battalion Doctor Queue	Separate Station's Medical Treatment Doctor Queue	Separate Station's Therapist Queue
1	0	0.33232	2	1	12	10	15	0.76471	0.47855
2	0	0.24804	1	1	12	9	16	1	0.45795
3	0	0.19397	2	1	11	9	14	1	0.38929
4	0	0.36487	2	1	11	9	14	1	0.41948
5	0	0.10541	2	1	11	9	13	1	0.41743
6	0	0.33271	2	1	10	9	14	1	0.45003
7	0	0.29494	2	1	10	9	15	1	0.39493
8	0	0.31598	1	1	10	9	14	1	0.3607
9	0	0.29124	1	1	10	9	15	1	0.33558
10	0	0.27843	1	1	10	9	15	1	0.31294
CUM. SUM	0	2.75791	15	11	106	91	146	10.94039	4.01688
AVERAGE	0	0.275791	2	1	11	9	15	1.094039	0.401688
VARIANCE	0	0.005899147	0.003880492	0.003713866	0.715436029	0.243438589	0.473683111	0.027454297	0.002900041
STAN. DEV	0	0.076805905	0.062293592	0.060941498	0.845834517	0.493394963	0.688246403	0.165693382	0.053852026
CONF. INT	0	0.047603848	0.038609201	0.037771182	0.524243255	0.305803294	0.42657107	0.102695783	0.033377169

Identifier	Average Time In Queue (minute)								
Replication	Separate Station's Surgeon Queue	30 Bed H. mergency Surge Unit's Surgeon Queue	30 Bed H. Normal Surgery Unit's Surgeon Queue	Separate St. Medical Treatment Bed Queue	Separate Station's Psycotherapy Unit Bed Queue	Separate Station's Surgery Unit Bed Queue	30 Bed H. Emergency Surgery Unit Bed Queue	30 Bed Hospital Normal Surgery Unit Bed Queue	
1	0.04368	10	82	49	0.39552	3098.3	2	724.93	
2	0.18825	24	64	290.58	2	2950.1	248.44	819.6	
3	0.40309	19	61	281.11	4	2945.7	182	762.31	
4	0.30678	18	68	262.78	183	2963	194	687.67	
5	0.2692	15	68	235.07	149	2844	174	682.24	
6	0.30117	15	71	470.28	131	2880.8	151	746.01	
7	0.27875	15	83	460.74	119.74	2857.2	133	1019.3	
8	0.28526	14	85	525.54	121	2759.4	122	945.53	
9	0.28241	13	81	472.91	131	2760.1	113	895.48	
10	0.28191	13	78	431.19	121.89	2738.9	105	905.63	
CUM. SUM	2.6405	156	740	3,480	962.48922	28817.5	1423.7204	8188.7	
AVERAGE	0.26405	16	74	348	96.248922	2881.75	142.37204	818.87	
VARIANCE	0.00868811	15.76045198	73.77746071	22077.5053	4570.843988	13123.31389	4339.156989	13647.26631	
STAN. DEV	0.093210033	3.969943574	8.589380694	148.5850103	67.60801719	114.5570333	65.87227785	116.8215148	
CONF. INT	0.05777103	2.460547662	5.323647602	92.09211491	41.90305115	71.00177505	40.82725012	72.4052873	

B. DISCRETE CHANGE VARIABLES (DSTATS)

APPENDIX D5: AVERAGE NUMBER OF PATIENT (To be continued)

Identifier	Number of Patient In Platoon1				Number of Patient In Company1				Number of Patient In Battalion1				Number of Patient In Battalion2			
Replication	Enter	Dutty	Dead	In System	Enter	Dutty	Dead	In System	Enter	Dutty	Dead	In System	Enter	Dutty	Dead	In System
1	29	10	6	13	15	3	0	12	244,33	78	28	138,7	234,21	76	34	124,17
2	27	9	5	14	15	3	0,78793	11	240,31	70	35	135,1	229,42	73	33	124,17
3	32	11	4	17	18	3	1	14	234,6	69	36	129,79	231,8	74	35	122,73
4	31	10	5	16	17	3	0,74147	14	235,22	73	37	125,61	232,73	74	35	124,03
5	30	9	4	17	17	3	0,75216	14	236,76	74	37	126,28	233,16	74	34	124,98
6	30	8	4	17	18	3	1	14	234,95	74	36	125,06	234,67	76	35	124,39
7	28	8	4	17	17	3	1	13	233,37	72	36	125,47	234,69	76	35	124,51
8	28	8	4	17	17	3	1	13	233,56	73	36	125,04	233,62	75	35	123,84
9	28	8	4	17	17	3	1	14	234,77	74	36	125,3	234,24	76	36	123,27
10	29	8	4	17	17	3	1	14	237,82	76	36	126,52	233,83	75	36	122,72
CUM. SUM	**293**	**90**	**45**	**161**	**169**	**32**	**7,29906**	**132**	**2365,69**	**733**	**354**	**1282,87**	**2332,37**	**751**	**348**	**1238,81**
AVERAGE	**29**	**9**	**5**	**16**	**17**	**3**	**0,729906**	**13**	**236,569**	**73**	**35**	**128,287**	**233,237**	**75**	**35**	**123,881**
VARIANCE	**1,9654568**	**1,4463317**	**0,3492694**	**1,9542525**	**1,2219224**	**0,0158729**	**0,0730729**	**0,9312737**	**11,85241**	**6,2476449**	**6,6120096**	**23,248601**	**2,6125789**	**1,2870637**	**0,6842813**	**0,56661**
STAN. DEV	**1,4019475**	**1,2026353**	**0,5909902**	**1,3979458**	**1,105406**	**0,1259877**	**0,2703201**	**0,9650253**	**3,4427329**	**2,4995289**	**2,5713828**	**4,8216803**	**1,6163474**	**1,1344883**	**0,827213**	**0,752735**
CONF. INT	**0,8689188**	**0,7453863**	**0,3662922**	**0,8664386**	**0,6851241**	**0,0780865**	**0,1675428**	**0,598117**	**2,1337856**	**1,5491933**	**1,5937279**	**2,9884491**	**1,0018026**	**0,7031492**	**0,5127017**	**0,4665407**

Identifier	Number of Patient In Battalion3				Number of Patient In Brigade Separate Station (Total)				Number of Patient In Brigade Separate Station's Medical Treatment				Number of Patient In Brigade Separate Station's Psycotherapy Unit			
Replication	Enter	Dutty	Dead	In System	Enter	Dutty	Dead	In System	Enter	Dutty	Dead	In System	Enter	Dutty	Dead	In System
1	113,23	33	19	62	175,25	4	3	169,11	61	2	1	58	52	2	0,63597	49
2	119,54	38	19	63	174,11	3	4	166,86	61	1	1	58	54	2	0,6456	52
3	116,76	38	17	63	178,02	4	4	170,8	64	2	1	61	54	1	0,50735	52
4	114,4	37	18	61	178,7	3	4	171,58	66	1	1	63	54	1	0,38051	52
5	115,49	38	18	60	178,19	3	4	171,46	66	1	1	64	54	1	0,30441	52
6	116,43	39	18	60	180,82	3	4	173,96	68	1	1	65	55	1	0,25368	53
7	114	37	17	61	180,34	3	4	173,58	68	1	1	65	54	1	0,27276	53
8	114,68	38	17	61	178,45	3	3	172,01	69	1	1	66	53	1	0,23866	52
9	114,36	37	17	61	177,34	3	3	170,83	68	1	1	66	52	1	0,21214	51
10	113,86	37	17	60	177,03	3	3	170,65	68	1	1	65	52	1	0,20033	51
CUM. SUM	**1152,75**	**371**	**176**	**611**	**1778,25**	**33**	**35**	**1710,84**	**657**	**13,5179**	**12**	**632**	**534**	**13**	**3,65141**	**517**
AVERAGE	**115,275**	**37**	**18**	**61**	**177,825**	**3**	**4**	**171,084**	**66**	**1,35179**	**1**	**63**	**53**	**1**	**0,365141**	**52**
VARIANCE	**3,5047167**	**2,8108882**	**0,6211802**	**1,1766715**	**4,2135389**	**0,0489381**	**0,1456185**	**4,2020711**	**9,5649548**	**0,0301005**	**0,00453**	**10,365155**	**1,0118636**	**0,0675996**	**0,0292979**	**1,4111558**
STAN. DEV	**1,8720889**	**1,6765704**	**0,7881499**	**1,0847449**	**2,0526906**	**0,2212196**	**0,3815999**	**2,0498954**	**3,0927261**	**0,173495**	**0,0673054**	**3,2194961**	**1,0059143**	**0,2599992**	**0,1711662**	**1,1879208**
CONF. INT	**1,1603097**	**1,0391284**	**0,4884907**	**0,6723185**	**1,2722456**	**0,1371106**	**0,2365134**	**1,2705131**	**1,9168534**	**0,1075312**	**0,0417155**	**1,9954247**	**0,6234598**	**0,161146**	**0,1060878**	**0,7362663**

APPENDIX D5: AVERAGE NUMBER OF PATIENT

Identifier	Number of Patient In Brigade Separate Station's Surgery Unit				Number of Patient In 30 Bed Hospital Emergency Surgery Unit				Number of Patient In 30 Bed Hospital Normal Surgery Unit				Number of Patient In Brigade 30 Bed Hospital (Total)			
Replication	Enter	Dutty	Dead	In System	Enter	Dutty	Dead	In System	Enter	Dutty	Dead	In System	Enter	Dutty	Dead	In System
1	62	0	1	61	36	0.08067	10	26	45	0	5	40	83	0	15	68
2	58	0.2936	2	56	37	0.16099	9	27	47	0.19499	4	43	85	0	13	72
3	59	0.71124	2	56	34	0.10732	9	25	46	0.47417	4	42	81	1	12	68
4	58	1	2	55	33	0.38689	9	25	44	0.42139	3	40	79	1	12	66
5	57	0.65674	2	54	33	0.50584	8	25	45	0.69756	4	41	80	1	12	67
6	57	0.70277	2	54	32	0.49507	8	24	46	0.73033	4	41	80	1	12	67
7	57	0.88841	2	54	31	0.68764	7	23	49	0.62599	4	44	82	1	12	69
8	55	0.79512	2	52	31	0.78467	7	23	48	0.58578	4	44	80	1	11	68
9	55	0.70677	2	53	31	0.69749	7	23	47	0.67541	4	43	80	1	12	67
10	55	0.71049	2	53	31	0.64586	8	23	47	0.63097	4	43	80	1	12	67
CUM. SUM	573	6.28607	20	547	329	4.55244	83	245	465	5.03659	40	421	809	10	123	679
AVERAGE	57	0.628607	2	55	33	0.455244	8	24	47	0.503659	4	42	81	1	12	68
VARIANCE	4.2033752	0.073947	0.1567519	6.5298535	4.4835437	0.0682564	0.8705003	2.3238085	2.3942949	0.0569977	0.1119771	1.9322347	3.2952805	0.2220365	1.0517274	2.7461341
STAN. DEV	2.0502134	0.271932	0.3959191	2.5553578	2.117438	0.2612592	0.9330061	1.5244043	1.5473509	0.2387419	0.3346298	1.3900485	1.8152908	0.4712075	1.0255376	1.6571464
CONF. INT	1.2707102	0.1685418	0.2453883	1.5837957	1.3123756	0.1619269	0.5782717	0.9448168	0.959039	0.1479708	0.2074016	0.8615439	1.1251065	0.2920516	0.6356222	1.0270896

Identifier	Number of Patient In 600 Bed Hospital				Number of Patient In Army Hospital				Number of Patient In Civilian Hospital				Number of Patient In Rehabilitation C.			
Replication	Enter	Dutty	Dead	In System	Enter	Dutty	Dead	In System	Enter	Dutty	Dead	In System	Enter	Dutty	Dead	In System
1	182.86	6	5	171.97	50	0.74994	0	49	104.2	3	2	100	8	0	0	8
2	181.87	5	3	173.33	51	0.40009	0.05141	51	102.21	3	1	98	8	0	0	8
3	190.03	5	3	181.38	53	0.42063	0.05263	53	98	3	1	95	8	0	0	8
4	189.05	5	4	180.57	51	0.38229	0.03947	50	101.43	3	0.94368	98	8	0	0	8
5	190.1	5	4	181.89	52	0.34633	0.03158	51	102.26	3	0.76905	99	8	0	0	8
6	191.17	5	4	182.22	51	0.28861	0.12634	51	101.88	3	0.82178	99	8	0	0	8
7	189.07	5	4	180.07	51	0.27581	0.13482	51	101.11	3	0.75368	98	8	0	0	8
8	188.86	5	4	179.91	51	0.30448	0.11797	51	101.04	2	0.75295	98	8	0	0	8
9	186.53	5	4	177.89	51	0.31647	0.10627	50	103	2	0.77401	100	8	0	0	8
10	187.07	5	4	177.99	50	0.30921	0.11861	50	103.74	2	0.76292	100.69	9	0	0.01095	9
CUM. SUM	1876.61	51	39	1787.22	511	3.79386	0.7791	507	1019.063	25	9.74447	985	81	0	0.01095	81
AVERAGE	187.661	5	4	178.722	51	0.379386	0.07791	51	101.9063	3	0.974447	98	8	0	0.001095	8
VARIANCE	9.7155433	0.1539924	0.1981801	12.430218	0.6906473	0.0193337	0.0022984	0.7524381	2.8264169	0.0176134	0.0936956	2.8719596	0.0837292	0	0	0.082428
STAN. DEV	3.1169766	0.3924187	0.4451742	3.5256514	0.8310519	0.1390457	0.0479412	0.8674319	1.6811951	0.1327155	0.3060974	1.6946857	0.28936	0	0	0.2871027
CONF. INT	1.9318838	0.2432188	0.2759163	2.185178	0.5150811	0.0861797	0.0297137	0.5376292	1.0419948	0.0822563	0.1897173	1.0503562	0.1793436	0	0	0.1779446

APPENDIX D7: NUMBER IN QUEUES (NQ)

Replication	Battalion 1 Doctor Queue	Battalion 3 Doctor Queue	Separate S. Medical Treatment Dr. Queue	Separate Station Therapist Queue	Separate Station Surgeon Queue	30 Bed H. Emergency Surgeon Queue	30 Bed H. Normal Surgeon Queue	Separate S. Medical Treatment Bed Queue	Separate Station Therapist Bed Queue	Separate Station Surgery Bed Queue	30 Bed H. Normal Surgery Bed Queue	30 Bed H. Emergency Surgery Bed Queue
1	0.42142	0.23326	0.00696	0.00362	3.64E-04	0.04773	0.54969	0.11647	0.01986	28	4	0.00897
2	0.39441	0.24522	0.00882	0.00355	0.00144	0.11986	0.43836	1	0.01401	25	5	1
3	0.35413	0.21574	0.01248	2.96E-03	0.00321	0.08568	0.3926	1	0.01508	25	5	0.7628
4	0.35481	0.21366	0.0129	0.00318	0.00241	0.08314	0.42366	0.94361	0.45218	25	4	0.81689
5	0.35254	0.2052	0.01138	0.00317	0.00208	0.07168	0.43246	0.80893	0.36345	23	4	0.73492
6	0.33436	0.22463	0.01072	0.0035	0.00232	0.06714	0.45928	1	0.31359	23	5	0.61244
7	0.32875	0.22445	0.01022	0.00306	0.00215	0.0632	0.56466	1	0.28305	23	7	0.52495
8	0.32319	0.2225	0.01012	0.00274	0.00213	0.0589	0.5656	2	0.282	22	6	0.47732
9	0.32501	0.2251	0.01014	2.53E-03	0.00213	0.05835	0.53185	2	0.30133	22	6	0.44578
10	0.33121	0.23525	0.01041	0.00233	0.00214	0.05524	0.52106	1	0.27954	22	6	0.40121
CUM. SUM	**3.51983**	**2.24501**	**0.10415**	**0.03064**	**0.020374**	**0.71092**	**4.87922**	**11.44221**	**2.32409**	**238**	**51**	**5.89808**
AVERAGE	**0.351983**	**0.224501**	**0.010415**	**0.003064**	**0.0020374**	**0.071092**	**0.487922**	**1.144221**	**0.232409**	**24**	**5**	**0.589808**
VARIANCE	**0.00105254**	**0.00013253**	**2.90505E-06**	**1.8887E-07**	**5.3256E-07**	**0.000435845**	**0.00425937**	**0.213693097**	**0.024907078**	**4.07674001**	**0.82436035**	**0.087458774**
STAN. DEV	**0.03244294**	**0.01151198**	**0.001704421**	**0.00043459**	**0.00072976**	**0.020876893**	**0.06526387**	**0.462269506**	**0.157819763**	**2.01909386**	**0.90794292**	**0.295734295**
CONF. INT	**0.02010794**	**0.00713506**	**0.00105639**	**0.00026936**	**0.0004523**	**0.012939375**	**0.04045016**	**0.286511919**	**0.09781576**	**1.25142249**	**0.56273768**	**0.183294376**

APPENDIX D8: UTILIZATION OF RESOURCES (NR)

Replication	Battalion 1 Doctor	Battalion 3 Doctor	Separate St. Medical Treatment Doctor	Separate Station Therapist	Separate Station Surgeon	30 Bed Hospital Emergency Surgeon	30 Bed Hospital Normal Surgeon	Separate St. Medical Treatment Bed	Separate Station Psycotherapy Bed	Separate Station Surgery Bed	30 Bed H. Normal Surgery Bed	30 Bed H. Emergency Surgery Bed
1	0.35028	0.15577	0.13759	0.22708	2.55E-01	0.22519	0.55252	6	6	11	13	11
2	0.35403	0.15871	0.13681	0.23135	0.23824	0.23734	0.5326	6	6	11	14	12
3	0.33929	0.15666	0.14225	0.22963	0.24735	0.219	0.50689	6	6	11	14	11
4	0.33914	0.15519	0.14282	0.22837	0.24244	0.22392	0.50064	7	6	11	13	11
5	0.34192	0.15735	0.14201	0.22887	0.23935	0.22381	0.50742	7	6	11	13	11
6	0.33985	0.15954	0.14307	0.23443	0.23976	0.21478	0.51614	7	6	11	14	10
7	0.33659	0.15845	0.14391	0.23393	0.24164	0.20617	0.54072	7	6	11	14	10
8	0.33632	0.16003	0.14454	0.22882	0.23468	0.20487	0.53907	7	6	11	14	10
9	0.33962	0.15923	0.14425	0.22639	0.23595	0.20706	0.53194	7	6	11	14	10
10	0.34358	0.16069	0.14333	0.22383	0.23654	0.20242	0.5337	7	6	11	13	10
CUM. SUM	**3.42062**	**1.58162**	**1.42058**	**2.2927**	**2.41104**	**2.16456**	**5.26164**	**67**	**61**	**114**	**135**	**105**
AVERAGE	**0.342062**	**0.158162**	**0.142058**	**0.22927**	**0.241104**	**0.216456**	**0.526164**	**7**	**6**	**11**	**13**	**11**
VARIANCE	**3.3676E-05**	**3.4192E-06**	**7.24017E-06**	**1.0739E-05**	**3.7604E-05**	**0.000128537**	**0.00029772**	**0.062510026**	**0.024371434**	**0.00354467**	**0.01011023**	**0.352169254**
STAN. DEV	**0.00580311**	**0.00184911**	**0.002690757**	**0.00327709**	**0.00613224**	**0.011337397**	**0.01725442**	**0.250020052**	**0.156113528**	**0.0595371**	**0.10054966**	**0.5934385**
CONF. INT	**0.00359673**	**0.00114607**	**0.001667715**	**0.00203112**	**0.00380073**	**0.007026852**	**0.01069419**	**0.154960957**	**0.096758246**	**0.03690075**	**0.06232009**	**0.36780969**

APENDIX E1 ***Tableau for Comparison of Two Systems***

Replication	Existing System, Time In Brigade Separate Station Surgery Unit (minute)	Proposed System, Time In Brigade Separate Station Surgery Unit (minute)
1	7127.2	5238.7
2	7056.9	5123.6
3	7135.7	5123.7
4	7104.5	5191.3
5	7085.1	5069.2
6	7117.2	5128.7
7	7121	5122.3
8	7108.1	5067.8
9	7082.4	5076.4
10	7032.9	5046.3
CUM. SUM	**70971**	**51188**
AVERAGE	**7097.1**	**5118.8**
VARIANCE	**1071.635556**	**3544.971111**
STAN. DEV	**32.73584512**	**59.53965998**

APPENDIX E 2

Replication	Time In System of Existing System Brigade 30 Bed Hospital (minute)	Time In System of Proposed System Brigade 30 Bed Hospital (minute)
1	9776.3	3739.3
2	9173.2	3699.4
3	9226	3766.9
4	9202.9	3692.7
5	9008	3676.6
6	8977.4	3719.1
7	8998.8	3954.1
8	9016.8	3897.2
9	9046.4	3843.8
10	9019.9	3824.4
CUM. SUM	**91445.7**	**37813.5**
AVERAGE	**9144.57**	**3781.35**
VARIANCE	**57698.54456**	**8935.149444**
STAN. DEV	**240.2052134**	**94.52591943**

APPENDIX E 3

Replication	Existing System, Time In Queue of Brigade Separate Station's Surgery Unit Bed (minute)	Proposed System, Time In Queue of Brigade Separate Station's Surgery Unit Bed (minute)
1	5284.2	3098.3
2	5194.3	2950.1
3	5245.9	2945.7
4	5222.9	2983
5	5210.3	2844
6	5261.9	2880.8
7	5250.5	2857.2
8	5248.6	2759.4
9	5227	2760.1
10	5179.9	2738.9
CUM. SUM	**52325.5**	**28817.5**
AVERAGE	**5232.55**	**2881.75**
VARIANCE	**1015.693889**	**13123.31389**
STAN. DEV	**31.86995276**	**114.5570333**

APPENDIX F 1: **Tableau for R & S, The Best Of k System Stage 1**

Replication	Existing System, Time in Brigade Separate Station's Surgery Unit (minute)	Proposed System Time in Brigade Separate Station's Surgery Unit (minute)	Revised Existing System 1 Time in Brigade Separate Station's Surgery Unit (minute)	Revised Existing System 2 Time in Brigade Separate Station's Surgery Unit (minute)	Revised Proposed System Time in Brigade Separate Station's Surgery Unit (minute)
1	7127.2	5238.7	2964.2	3102.4	2796.5
2	7056.9	5123.6	2989.3	3069.5	2843.3
3	7135.7	5123.7	3001.5	3061.8	2880.7
4	7104.5	5191.3	3028.8	3057.9	2896.4
5	7085.1	5069.2	3015.3	3041.6	2892.4
6	7117.2	5128.7	3015.6	3027.7	2896.3
7	7121	5122.3	3009.8	3015.1	2914.9
8	7108.1	5067.8	3010.7	3017.1	2923
9	7082.4	5076.4	3009.9	3017.9	2908.1
10	7032.9	5046.3	3006.9	3006.3	2908.8
11	7045.8	5019.4	3006.7	3001	2905.7
12	7063	5024.5	3007.2	3007.5	2911.6
13	7040.8	4978.4	3006.4	3003.5	2914.2
14	7054.5	5000.6	3006.4	2998.9	2910.4
15	7060.6	4943.3	3007.7	2996.7	2914.7
16	7035.1	4948.2	3011.4	2997.1	2926.2
17	7052	4937.2	3008.3	2993.1	2927.2
18	7060.8	4918.6	3006.7	2995.4	2931.1
19	7054	4910.3	3004.8	2998.3	2923.9
20	7049.9	4924.6	3002.6	3000.8	2925.5
CUM. SUM	**141487.5**	**100793.1**	**60120.2**	**60409.6**	**58050.9**
AVERAGE	**7074.375**	**5039.655**	**3006.01**	**3020.48**	**2902.545**
VARIANCE	**1089.924079**	**9117.445763**	**150.0262105**	**928.4069474**	**1024.023658**
STAN. DEV	**33.01399823**	**95.485317**	**12.24851871**	**30.46977104**	**32.00036965**

APPENDIX F2: **Tableau for R & S, The Best Of k System Stage 1 (minute)**

Replication	Existing System Time In System of Brigade 30 Bed Hospital (minute)	Proposed System Time In System of Brigade 30 Bed Hospital (minute)	Revised Existing System 1 Time In System of Brigade 30 Bed Hospital (minute)	Revised Existing System 2 Time In System of Brigade 30 Bed Hospital (minute)	Revised Proposed System Time In System of Brigade 30 Bed Hospital (minute)
1	9776.3	3739.3	6361.6	6424.7	3553
2	9173.2	3699.4	6181.5	6815.7	3251.7
3	9226	3766.9	6363.4	6855.7	3289.4
4	9202.9	3692.7	6410.7	6959.7	3275.6
5	9008	3676.6	6398.4	6790.5	3372.1
6	8977.4	3719.1	6363.6	6689.7	3422.7
7	8998.8	3954.1	6409.8	6638.7	3436.4
8	9016.8	3897.2	6414.3	6611.2	3490.1
9	9046.4	3843.8	6433.4	6595.1	3449.5
10	9019.9	3824.4	6416.3	6545.5	3510.6
11	8939.9	3804.7	6498.8	6536.3	3485.1
12	8973.4	3820.1	6467	6567	3481.1
13	8912.3	3799.4	6450.3	6573.6	3492.2
14	8919.2	3769.2	6455.5	6584.1	3533.5
15	8919.6	3739	6461.1	6560.4	3510.3
16	8912	3719.6	6484.4	6618.7	3494
17	8907.8	3692.9	6457.8	6597.9	3527.6
18	8941.7	3665.9	6465.4	6621.1	3507.8
19	8937.3	3640	6485	6604.9	3505.9
20	8911.8	3619.3	6510.5	6598.5	3525
CUM. SUM	**180720.7**	**75083.6**	**128488.8**	**132789**	**69113.6**
AVERAGE	**9036.035**	**3754.18**	**6424.44**	**6639.45**	**3455.68**
VARIANCE	**39930.48661**	**7430.057474**	**5237.078316**	**15702.15947**	**8021.602737**
STAN. DEV	**199.8261409**	**86.19778114**	**72.3676607**	**125.3082578**	**89.56340065**

APPENDIX F3: **Tableau for R & S, The Best Of k System Stage 1 (minute)**

Replication	Existing System Time In Queue of Separate Station Surgery Unit Bed (minute)	Proposed System Time In Queue of Separate Station Surgery Unit Bed (minute)	Revised Existing System 1 Time In Queue of Separate Station Surgery Unit Bed (minute)	Revised Existing System 2 Time In Queue of Separate Station Surgery Unit Bed (minute)	Revised Proposed System Time In Queue of Separate Station Surgery Unit Bed (minute)
1	5284.2	3098.3	0	70	0
2	5194.3	2950.1	9	43	0.13843
3	5245.9	2945.7	9	31	0.09372
4	5222.9	2983	39	24	0.07034
5	5210.3	2844	32	19	0.05694
6	5261.9	2880.8	27	16	0.0473
7	5250.5	2857.2	23	14	0.04056
8	5248.6	2759.4	21	14	0.03485
9	5227	2760.1	19	16	0.03127
10	5179.9	2738.9	18	15	0.02812
11	5203.6	2707.9	16	14	0.53835
12	5209.7	2717.3	15	14	0.4982
13	5192.4	2670	14	13	0.46295
14	5205.1	2682.8	13	12	0.4344
15	5210.9	2611.9	12	11	0.40555
16	5180.1	2612.9	11	11	0.38007
17	5196	2599.3	11	10	0.35522
18	5202.5	2581	10	10	0.33711
19	5192.8	2572.6	10	9	0.31742
20	5190.9	2578.8	9	9	0.29892
CUM. SUM	104309.5	55152	317.4177	317	4.56972
AVERAGE	5215.475	2757.6	15.870885	19	0.228486
VARIANCE	832.0682895	23905.92105	81.26981601	214.8854057	0.035725877
STAN. DEV	28.84559393	154.6153972	9.014977316	14.65897014	0.189012902

APPENDIX G 1 ***Tableau for R & S, The Best Of k System Stage 2 (minute)***

Time in Brigade Separate Station's Surgery Unit

Replication	Existing System, Time In Brigade Separate Station's Surgery Unit	Proposed System, Time In Brigade Separate Station's Surgery Unit	Revised Existing System 1, Time In Separate Station's Surgery Unit	Revised Existing System 2, Time In Separate Station's Surgery Unit	Revised Proposed System , Time In Separate Station's Surgery Unit
21	7048.8	4922.5	3002.2	3001.9	2924.9
22	7028.3	4958.3		2999.4	2923
23	7025.1	4942.9		2999.6	2918.1
24	7023.8	4909.1		3000.5	2918.6
25	7039.9	4922.3		2998.1	2918.6
26	7037.2	4930.4			2918.7
27	7044.8	4938.5			2917.9
28	7032.8	4899.4			2916.9
29	7032.8	4882.3			
30		4894.3			
AVERAGE	**7034.833333**	**4920**	**3002.2**	**2999.9**	**2919.5875**

APPENDIX G 2 ***Tableau for R & S, The Best Of k System Stage 2 (minute)***

Time In System of Brigade 30 Bed Hospital

Replication	Existing System Time In System of 30 Bed Hospital	Proposed System Time In System of 30 Bed Hospital	Revised Existing System 1 Time In System of 30 Bed Hospital	Revised Existing System 2 Time In System of 30 Bed Hospital	Revised Proposed System Time In System of 30 Bed Hospital
21	8926.7	3632.2	6503.9	6614.6	3566.7
22	8884.7				
23	8872				
24	8903.7				
25	8921.6				
26	8905.8				
27	8891.8				
28	8845.5				
29	8847.3				
30	8834.7				
AVERAGE	**8883.38**	**3632.2**	**6503.9**	**6614.6**	**3566.7**

APPENDIX G 3 ***Tableau for R & S, The Best Of k System Stage 2 (minute)***

Time In Queue of Brigade Separate Station's Surgery Unit Bed

Replication	Existing System, Time In Queue of Separate Station's Surgery Unit Bed	Proposed System, TimeIn Queue of Separate Station's Surgery Unit Bed	Revised Existing Sys.1, TimeIn Q. of Separate Station's Surgery Unit Bed	Revised Existing Sys. 2, TimeIn Q. of Separate Station's Surgery Unit Bed	Revised Proposed System, TimeIn Q. of Separate Station's Surgery Unit Bed
21	5187.7	2568.9	9	8	0.28271
22	5167.8	2608.5			
23	5165.2	2586.9			
24		2547.2			
25		2561.5			
26		2571			
27		2581.7			
28		2536.2			
29		2521.9			
30		2532.5			
AVERAGE	**5173.566667**	**2561.63**	**9**	**8**	**0.28271**

ANALYSIS OF THE ALTERNATIVE SCENARIOS UNDER INCREASED ARRIVAL RATES

APPENDIX H1: Time In Queue for Doctor of First Battalion' of The Existing and Proposed System

	Existing System, Time in Queue for Doctor of First Battalion (minute)			Proposed System, Time in Queue for Doctor of First Battalion (minute)		
Replication Number	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6
1	10	14	97	12	12	187.56
2	11	14	116.89	12	14	166.06
3	11	14	96	11	13	161.9
4	10	15	111.18	11	13	201
5	11	15	120.59	11	13	178.04
6	11	15	126.69	10	13	174.4
7	11	15	119.23	10	13	166.65
8	11	15	113.05	10	13	159.74
9	10	15	113.61	10	13	159.45
10	10	14	118.3	10	13	159.4
Average	11	15	113	11	13	171.42

APPENDIX H2: Time In Queue for Doctor of Second Battalion of the Existing and Proposed System

	Existing System, Time in Queue for Doctor of Second Battalion (minute)			Proposed System, Time in Queue for Doctor of Second Battalion (minute)		
Replication Number	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6
1	6	15	84	10	14	100
2	8	14	77	9	13	124.51
3	8	13	74	9	14	169.13
4	9	13	109.54	9	14	140.84
5	9	13	129.86	9	14	138.14
6	9	12	120.93	9	13	132.53
7	9	12	113.77	9	13	120.24
8	9	12	106.25	9	13	118.87
9	9	12	104.4	9	13	113.88
10	9	12	108.36	9	12	110.14
Average	9	13	103	9	13	127

APPENDIX H3: Time In Brigade Separate Station 's Medical Treatment Unit Bed Queue of The Existing and Proposed System

	EXISTING SYSTEM TIME IN QUEUE FOR BED OF BRIGADE SEPARATE STATION'S MEDICAL TREATMENT (minute)			PROPOSED SYSTEM TIME IN QUEUE FOR BED OF BRIGADE SEPARATE STATION'S MEDICAL TREATMENT UNIT (minute)		
Replication Number	**Scenario 1**	**Scenario 2**	**Scenario 3**	**Scenario 4**	**Scenario 5**	**Scenario 6**
1	1442.3	2695.3	3147.6	49	2771.6	4098.2
2	2023.6	2863.7	3231.3	290.58	2420.7	4163.7
3	2083.2	2904.9	3117	281.11	2285.6	3997 2
4	2270 2	2995 8	3063.9	262.78	2396 2	4019 7
5	2224 4	3109	2994	235.07	2717 6	3767 3
6	2035 9	3051 6	3016.2	470 28	2729.3	3744.6
7	1836.5	3166.8	3019.6	460.74	2773.4	3710 7
8	1835 2	3195	2984.8	525.54	2787.8	3727 7
9	1881.5	3141.9	2959.8	472.91	2826.1	3741.5
10	1944.8	3096	3009.6	431.19	2819.8	3768
Average	**1957.76**	**3022.1**	**3054.38**	**348**	**2652.81**	**3873.86**

APPENDIX H4: Time In Brigade Separate Station 's Psychotherapy Unit Bed Queue of The Existing and Proposed System

	EXISTING SYSTEM TIME IN BRIGADE SEPARATE STATION'S PSYCHOTHERAPY UNIT BED QUEUE (minute)			PROPOSED SYSTEM TIME IN BRIGADE SEPARATE STATION'S PSYCHOTHERAPY UNIT BED QUEUE (minute)		
Replication Number	**Scenario 1**	**Scenario 2**	**Scenario 3**	**Scenario 4**	**Scenario 5**	**Scenario 6**
1	95	1989.7	3395.7	0.39552	2608.6	2549.8
2	1365.7	2539.3	3217.1	2	2211.1	2877 8
3	1697 4	2608.9	3197.9	4	1729.5	3037.3
4	2034.6	2829	2914.3	183	1510.8	3000 3
5	1990.9	2912.9	2935.7	149	1651.3	3108 1
6	2065 7	3015.6	2863	131	1701.7	3154.5
7	2048.1	3000.9	2784.4	119.74	1755 7	3142.7
8	1982 3	2933	2823	121	1806.7	3178.9
9	2012 4	3004	2770	131	1873.3	3084.8
10	2016.1	3034.2	2795.1	121.89	1888.7	3152 3
Average	**1730.8677**	**2786.75**	**2969.62**	**96.248922**	**1873.74**	**3028.65**

APPENDIX H5: Time In Brigade Separate Station's Surgical Operation Unit Bed Queue of The Existing and Proposed System

	EXISTING SYSTEM TIME IN BRIGADE SEPARATE STATION'S SURGICAL OPERATION UNIT BED QUEUE (minute)			PROPOSED SYSTEM TIME IN BRIGADE SEPARATE STATION'S SURGICAL OPERATION UNIT BED QUEUE (minute)		
Replication Number	**Scenario 1**	**Scenario 2**	**Scenario 3**	**Scenario 4**	**Scenario 5**	**Scenario 6**
1	5284.2	5503.2	5672	3098.3	4241.6	5120.3
2	5194 3	5314.5	5597 2	2950.1	4496	5051.1
3	5245.9	5283.3	5466.4	2945.7	4416 3	4985.1
4	5222.9	5267 7	5490.5	2983	4347 3	4944.6
5	5210 3	5329.1	5452.5	2844	4431 3	4970
6	5261 9	5436	5490.4	2880.8	4367.1	4971.1
7	5250.5	5446.8	5452 7	2857.2	4400.8	5023 2
8	5248.6	5458.1	5452.1	2759.4	4351.3	5031.4
9	5227	5446.1	5480.9	2760.1	4387.1	5039.5
10	5179 9	5461.8	5467.6	2738.9	4420.6	5045 8
Average	**5232.55**	**5394.66**	**5502.23**	**2881.75**	**4385.94**	**5018.21**

APPENDIX H6: Time In Brigade 30 Bed Hospital Emergency and Normal Surgical Operation Surgery Queue of The Proposed System

	PROPOSED SYSTEM TIME IN BRIGADE 30 BED HOSPITAL'S EMERGENCY SURGICAL OPERATION UNIT SURGEON QUEUE (minute)			PROPOSED SYSTEM TIME IN BRIGADE 30 BED HOSPITAL'S NORMAL SURGICAL OPERATION UNIT SURGEON QUEUE (minute)		
Replication Number	Scenario 4	Scenario 5	Scenario 6	Scenario 4	Scenario 5	Scenario 6
1	10	20	40	82	735.95	2767
2	24	18	32	64	610	2297.9
3	19	18	33	61	753.2	2063.8
4	18	17	31	68	725.16	2206.7
5	15	17	30	68	669.38	2173.4
6	15	16	34	71	633.51	2218.6
7	15	16	33	83	738.38	2209.1
8	14	15	33	85	681.68	2090.2
9	13	15	33	81	726.19	2115.1
10	13	16	32	78	710.44	2050.8
Average	16	17	33	74	698.389	2219.26

APPENDIX H7: Time In Brigade 30 Bed Hospital Emergency and Normal Surgical Operation Unit Bed Queue of The Proposed System

	PROPOSED SYSTEM TIME IN BRIGADE 30 BED HOSPITAL'S EMERGENCY SURGICAL OPERATION UNIT BED QUEUE (minute)			PROPOSED SYSTEM TIME IN BRIGADE 30 BED HOSPITAL'S NORMAL SURGICAL OPERATION UNIT BED QUEUE (minute)		
Replication Number	Scenario 4	Scenario 5	Scenario 6	Scenario 4	Scenario 5	Scenario 6
1	2	2109.3	3177.1	724.93	3075.8	3338.9
2	248.44	1931.8	3236	819.6	2936.1	3126.4
3	182	2075.2	3320.8	762.31	3011.7	3240.2
4	194	2044.3	3209.4	687.67	3065.7	3102.5
5	174	2056.1	3223.1	682.24	2986.5	3178.2
6	151	2113.3	3303.7	746.01	3063.4	3157.7
7	133	2151.9	3294	1019.3	3071.8	3151.5
8	122	2163.7	3293.5	945.53	3015.2	3121.1
9	113	2019.5	3315.3	895.48	2959.4	3074.5
10	105	1928.5	3271.3	905.63	2896.7	3060.1
Average	142.37234	2059.36	3264.42	818.87	3008.23	3155.11

APPENDIX H8: Number of Patient in First Battalion's Doctor Queue of The Existing and Proposed System

	EXISTING SYSTEM NUMBER OF PATIENT IN FIRST BATTALION'S DOCTOR QUEUE (NQ)			PROPOSED SYSTEM NUMBER OF PATIENT IN FIRST BATTALION'S DOCTOR QUEUE (NQ)		
Replication Number	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6
1	0.31137	1	9	0.42142	1	18
2	0.37308	1	11	0.39441	1	16
3	0.35561	1	9	0.35413	1	16
4	0.33375	1	11	0.35481	1	20
5	0.3517	1	11	0.35254	1	17
6	0.34337	1	12	0.33436	1	17
7	0.3512	1	11	0.32875	1	16
8	0.33997	1	11	0.32319	1	15
9	0.33742	1	11	0.32501	1	15
10	0.34006	1	11	0.33121	1	15
Average	0.343753	1	11	0.351983	1	17

APPENDIX H9: Number of Patient in Second Battalion's Doctor Queue of The Existing and Proposed System

	EXISTING SYSTEM NUMBER OF PATIENT IN SECOND BATTALION'S DOCTOR QUEUE (N			PROPOSED SYSTEM NUMBER OF PATIENT IN SECOND BATTALION'S DOCTOR QUEUE (NQ)		
Replication Number	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6
1	0	1	8	0	1	10
2	0	1	7	0	1	12
3	0	1	7	0	1	16
4	0	1	10	0	1	14
5	0	1	12	0	1	13
6	0	1	11	0	1	13
7	0	1	11	0	1	12
8	0	1	10	0	1	11
9	0	1	10	0	1	11
10	0	1	10	0	1	11
Average	0	1	10	0	1	12

APPENDIX H10: Number of Patient In Brigade Separate Station's Medical Treatment Unit Bed Queue (NQ) of The Existing and Proposed System

	EXISTING SYSTEM NUMBER OF PATIENT IN BRIGADE SEPARATE STATIO MEDICAL TREATMENT BED QUEUE (NQ)			PROPOSED SYSTEM NUMBER OF PATIENT (NQ) IN BRIGADE SEPARATE STATION'S MEDICAL TREATMENT BED QUEUE		
Replication Number	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6
1	8	22	30	0 11647	18	41
2	14	24	27	1	16	39
3	14	25	26	1	14	37
4	16	26	25	0.94361	16	37
5	15	27	26	0.80893	19	34
6	14	26	27	1	18	34
7	13	27	27	1	19	33
8	13	28	26	2	19	33
9	13	27	26	2	19	34
10	14	27	26	1	19	34
Average	13	26	27	1.144221	18	36

APPENDIX H11: Number of Patient (NQ) In Brigade Separate Station's Psychotherapy Unit Bed Queue of The Existing and Proposed System

	EXISTING SYSTEM NUMBER OF PATIENT (NQ) IN BRIGADE SEPARATE S PSYCHOTHERAPY UNIT BED QUEUE			PROPOSED SYSTEM NUMBER OF PATIENT (NQ) IN BRIGADE SEPARATE STATION'S PSYCHOTHERAPY UNIT BED QUEUE		
Replication Number	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6
1	0.50395	11	25	0.01986	13	18
2	7	14	24	0.01401	10	20
3	9	16	23	0.01508	8	21
4	11	17	21	0.45218	7	21
5	11	17	21	0.36345	8	23
6	11	18	20	0.31359	8	22
7	11	18	20	0.28305	9	22
8	11	17	20	0.282	9	22
9	10	18	19	0.30133	9	22
10	10	19	19	0.27954	9	22
Average	9.051665	17	21	0.232409	9	21

APPENDIX H12: Number of Patient (NQ) In Brigade Separate Station Surgical Operation Unit Bed Queue of The Existing and Proposed System

	EXISTING SYSTEM NUMBER OF PATIENT (NQ) IN BRIGADE SEPARATE S SURGICAL OPERATION UNIT BED QUEUE			PROPOSED SYSTEM NUMBER OF PATIENT (NQ) IN BRIGADE SEPARATE STATION'S SURGICAL OPERATION UNIT BED QUEUE		
Replication Number	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6
1	105.15	122.83	144.7	28	56	104.42
2	99	118.57	141.44	25	62	109.65
3	95	117.85	139.63	25	69	109.46
4	95	120.42	136.3	25	71	108.85
5	96	121.95	133.41	23	74	110.8
6	97	122.33	132.07	23	72	109.42
7	98	124.9	130.73	23	72	111.27
8	97	125.86	130	22	71	110.45
9	96	126.22	130.97	22	72	111.13
10	98	126.64	131.03	22	73	111.78
Average	97.4307	122.757	135.028	24	69	109.723

APPENDIX H13: Number of Patient (NQ) In Brigade 30 Bed Hospital Emergency and Normal Surgical Operation Surgery Queue of The Proposed System

	PROPOSED SYSTEM NUMBER OF PATIENT (NQ) IN BRIGADE 30 BED HOSPITAL'S EMERGENCY SURGICAL OPERATION UNIT SURGERY QUEUE			PROPOSED SYSTEM NUMBER OF PATIENT (NQ) IN BRIGADE 30 BED HOSPITAL'S NORMAL SURGICAL OPERATION UNIT SURGERY QUEUE		
Replication Number	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6
1	0.04773	0	1	0.54969	10	54
2	0.11986	0	0	0.43836	8	45
3	0.08568	0	0	0.3926	10	40
4	0.08314	0	0	0.42366	9	42
5	0.07168	0	0	0.43246	9	41
6	0.06714	0	0	0.45928	8	42
7	0.0632	0	0	0.56466	10	41
8	0.0589	0	0	0.5656	9	38
9	0.05835	0	0	0.53185	9	38
10	0.05524	0	0	0.52106	9	37
Average	0.071092	0	0	0.487922	9	42

APPENDIX H14: Number of Patient In Brigade 30 Bed Hospital Emergency and Normal Surgical Operation Unit Bed Queue of The Proposed System

	PROPOSED SYSTEM NUMBER OF PATIENT (NQ) IN BRIGADE 30 BED HOSPITAL'S EMERGENCY SURGICAL OPERATION UNIT BED QUEUE			PROPOSED SYSTEM NUMBER OF PATIENT (NQ) IN BRIGADE 30 BED HOSPITAL'S NORMAL SURGICAL OPERATION UNIT BED QUEUE		
Replication Number	Scenario 4	Scenario 5	Scenario 6	Scenario 4	Scenario 5	Scenario 6
1	0.00897	16	39	4	36	37
2	1	15	40	5	33	35
3	0.7628	15	41	5	34	37
4	0.81689	15	39	4	35	35
5	0.73492	16	39	4	34	36
6	0.61244	16	40	5	35	36
7	0.52495	17	41	7	35	36
8	0.47732	17	41	6	34	36
9	0.44578	16	42	6	33	35
10	0.40121	15	42	6	33	35
Average	0.589808	16	41	5	34	36

ANSWER TO THE ANALYSIS OF THE SCENARIOS UNDER INCREASED ARRIVAL RATES

APPENDIX H1A: Solution for The Time In First Battalion's Doctor Queue of The Existing and Proposed System Under Increased Arrival Rates

	EXISTING SYSTEM TIME IN FIRST BATTALION'S DOCTOR QUEUE (minute)			PROPOSED SYSTEM TIME IN FIRST BATTALION'S DOCTOR QUEUE (minute)		
Replication Number	First Scenario	Second Scenario	Third Scenario	First Scenario	Second Scenario	Third Scenario
1	13	12	1	7	18	2
2	11	12	1	10	17	2
3	10	12	2	10	16	2
4	9	13	2	10	15	2
5	9	12	2	10	15	2
6	9	13	2	10	15	2
7	9	13	2	10	14	2
8	9	13	2	10	15	2
9	8	13	2	10	15	2
10	8	13	2	10	14	2
Average	10	13	2	10	15	1.62583

APPENDIX H2A: Solution for The Time In Second Battalion's Doctor Queue of The Existing and Proposed System Under Increased Arrival Rates

	EXISTING SYSTEM TIME IN SECOND BATTALION'S DOCTOR QUEUE (minute)			PROPOSED SYSTEM TIME IN SECOND BATTALION'S DOCTOR QUEUE (minute)		
Replication Number	First Scenario	Second Scenario	Third Scenario	First Scenario	Second Scenario	Third Scenario
1	9	12	1	7	10	1
2	9	12	1	8	11	1
3	8	12	1	8	12	1
4	8	12	1	7	12	1
5	9	13	1	8	12	1
6	8	13	1	7	13	1
7	8	13	1	8	13	1
8	8	12	1	8	13	1
9	8	13	1	8	13	1
10	8	13	1	8	13	1
Average	8	12	1	8	12	1

APPENDIX H3A: Solution for The Time In Brigade Separate Station Medical Treatment Unit Bed Queue of The Existing and Proposed System Under Increased Arrival Rates

	EXISTING SYSTEM TIME IN BRIGADE SEPARATE STATION'S MEDICAL TREATMENT BED QUEUE (minute)			PROPOSED SYSTEM TIME IN BRIGADE SEPARATE STATION'S MEDICAL TREATMENT BED QUEUE (minute)		
Replication Number	First Scenario	Second Scenario	Third Scenario	First Scenario	Second Scenario	Third Scenario
1	0	22	9	0	0	0
2	17	29	30	0	0	0
3	74	19	52	12	0	0
4	57	15	45	42	0	0.2336
5	48	16	38	36	0	0.19182
6	41	14	32	31	0	14
7	36	13	28	26	0	12
8	32	11	25	22	0	11
9	28	11	47	22	0	10
10	52	10	46	20	0	9
Average	38.3909	15.8636	35.21327	21	0	5.549442

APPENDIX H4A: Solution for The Time In Brigade Separate Station Psychotherapy Unit Bed Queue of The Existing and Proposed System Under Increased Arrival Rates

	EXISTING SYSTEM TIME IN BRIGADE SEPARATE STATION'S PSYCHOTHERAPY UNIT BED QUEUE (minute)			PROPOSED SYSTEM TIME IN BRIGADE SEPARATE STATION'S PSYCHOTHERAPY UNIT BED QUEUE (minute)		
Replication Number	First Scenario	Second Scenario	Third Scenario	First Scenario	Second Scenario	Third Scenario
1	0	2	0	0	0	0
2	0	10	0	0	0	0.97554
3	0	20	0	0	0	0.66073
4	0	15	0	3	0	4
5	0	15	0	7	0	14
6	0.68072	16	0.298	6	0	11
7	0.5741	24	2	13	0	13
8	0.50692	23	1	12	0	14
9	0.71729	27	2	11	0	12
10	0.63804	41	2	10	0	11
Average	0.311707	19.1682	0.74927	6.28535	0	7.973587

APPENDIX H5A: Solution for The Time In Brigade Separate Station Surgical Operation Unit Bed Queue of The Existing and Proposed System Under Increased Arrival Rates

	EXISTING SYSTEM TIME IN BRIGADE SEPARATE STATION'S SURGICAL OPERATION UNIT BED QUEUE (minute)			PROPOSED SYSTEM TIME IN BRIGADE SEPARATE STATION'S SURGICAL OPERATION UNIT BED QUEUE (minute)		
Replication Number	First Scenario	Second Scenario	Third Scenario	First Scenario	Second Scenario	Third Scenario
1	0	18	27912	2	52	0
2	1	15	2	1	35	3
3	0.70996	12	4	7	24	2
4	0.53283	18	14	5	20	1
5	29	15	12	4	19	1
6	25	15	10	3	17	1
7	21	16	17	4	16	2
8	19	15	25	5	14	4
9	19	14	13	4	13	4
10	17	25	12	4	13	3
Average	13.278809	16.4675	12.08703333	3.86822	22.2231	2.19631

APPENDIX H6A: Solution for The Time In Brigade 30 Bed Hospital Emergency and Normal Surgical Operation Surgery Queue of The Proposed System Under Increased Arrival Rates

	PROPOSED SYSTEM TIME IN BRIGADE 30 BED HOSPITAL'S EMERGENCY SURGICAL OPERATION UNIT SURGERY QUEUE (minute)			PROPOSED SYSTEM TIME IN BRIGADE 30 BED HOSPITAL'S NORMAL SURGICAL OPERATION UNIT SURGERY QUEUE (minute)		
Replication Number	First Scenario	Second Scenario	Third Scenario	First Scenario	Second Scenario	Third Scenario
1	7	22	33	9	20	7
2	7	23	31	8	16	7
3	7	27	28	6	16	7
4	6	23	32	8	15	7
5	6	21	30	8	15	7
6	7	21	32	8	16	7
7	7	20	31	8	15	7
8	8	19	31	7	16	6
9	10	20	31	7	18	6
10	9	19	32	7	18	7
Average	7	22	31	8	16.3719	6.76949

APPENDIX H7A: Solution for The Time In Brigade 30 Bed Hospital Emergency and Normal Surgical Operation Unit Bed Queue of The Proposed System Under Increased Arrival Rates

	PROPOSED SYSTEM TIME IN BRIGADE 30 BED HOSPITAL'S EMERGENCY SURGICAL OPERATION UNIT BED QUEUE (minute)			PROPOSED SYSTEM TIME IN BRIGADE 30 BED HOSPITAL'S NORMAL SURGICAL OPERATION UNIT BED QUEUE (minute)		
Replication Number	First Scenario	Second Scenario	Third Scenario	First Scenario	Second Scenario	Third Scenario
1	1	84	26	0	33	39
2	1	46	31	12	21	29
3	9	61	22	79	17	20
4	7	47	24	48	13	20
5	6	38	20	40	21	21
6	5	67	26	33	23	24
7	5	61	27	32	21	21
8	4	55	24	31	25	20
9	4	58	22	30	51	23
10	3	52	33	29	53	35
Average	4.574	58.6557	25.4153	33.3938	27.6739	25.0712

APPENDIX H8A: Solution forThe Number of Patient in First Battalion's Doctor Queue of The Existing and Proposed System Under Increased Arrival Rates

	EXISTING SYSTEM NUMBER OF PATIENT IN FIRST BATTALION'S DOCTOR QUEUE (NQ)			PROPOSED SYSTEM NUMBER OF PATIENT IN FIRST BATTALION'S DOCTOR QUEUE (NQ)		
Replication Number	First Scenario	Second Scenario	Third Scenario	First Scenario	Second Scenario	Third Scenario
1	0.4674	1	0	0.22387	1	0
2	0.39267	1	0	0.30704	1	0
3	0.34639	1	0	0.32861	1	0
4	0.32645	1	0	0.32423	1	0
5	0.3195	1	0	0.32774	1	0
6	0.30569	1	0	0.32553	1	0
7	0.29295	1	0	.32761	1	0
8	0.28746	1	0	0.31887	1	0
9	0.28249	1	0	0.32063	1	0
10	0.27936	1	0	0.32499	1	0
Average	0.330036	1	0	0.311278889	1	0

APPENDIX H9A: Solution for The Number of Patient in Second Battalion's Doctor Queue of The Existing and Proposed System Under Increased Arrival Rates

	EXISTING SYSTEM NUMBER OF PATIENT IN SECOND BATTALION'S DOCTOR QUEUE (NQ)			PROPOSED SYSTEM NUMBER OF PATIENT IN SECOND BATTALION'S DOCTOR QUEUE (NQ)		
Replication Number	First Scenario	Second Scenario	Third Scenario	First Scenario	Second Scenario	Third Scenario
1	0	1	0	0	1	0
2	0	1	0	0	1	0
3	0	1	0	0	1	0
4	0	1	0	0	1	0
5	0	1	0	0	1	0
6	0	1	0	0	1	0
7	0	1	0	0	1	0
8	0	1	0	0	1	0
9	0	1	0	0	1	0
10	0	1	0	0	1	0
Average	0	1	0	0	1	0

APPENDIX H10A: Solution for The Number of Patient In Brigade Separate Station 's Medical Treatment Unit Bed Queue (NQ) of The Existing and Proposed System Under Increased Arrival Rates

	EXISTING SYSTEM NUMBER OF PATIENT IN BRIGADE SEPARATE STATION'S MEDICAL TREATMENT BED QUEUE (NQ)			PROPOSED SYSTEM NUMBER OF PATIENT (NQ) IN BRIGADE SEPARATE STATION'S MEDICAL TREATMENT BED QUEUE		
Replication Number	First Scenario	Second Scenario	Third Scenario	First Scenario	Second Scenario	Third Scenario
1	0	0	0	0	0	0
2	0	0	0	0	0	0
3	1	0	0	0	0	0
4	0	0	0	0.13474	0	0
5	0	0	0	0.10779	0	0
6	0	0	0	0	0	0
7	0	0	0	0	0	0
8	0	0	0	0	0	0
9	0	0	0	0	0	0
10	0	0	0	0	0	0
Average	0	0	0	0.064459	0	0

APPENDIX H11A: Solution for The Number of Patient (NQ) In Brigade Separate Station's Psychotherapy Unit Bed Queue of The Existing and Proposed System Under Increased Arrival Rates

	EXISTING SYSTEM NUMBER OF PATIENT (NQ) IN BRIGADE SEPARATE STATION'S PSYCHOTHERAPY UNIT BED QUEUE			PROPOSED SYSTEM NUMBER OF PATIENT (NQ) IN BRIGADE SEPARATE STATION'S PSYCHOTHERAPY UNIT BED QUEUE		
Replication Number	First Scenario	Second Scenario	Third Scenario	First Scenario	Second Scenario	Third Scenario
1	0	0	0	0	0	0
2	0	0	0	0	0	0
3	0	0	0	0	0	0
4	0	0	0	0.00756	0	0
5	0	0	0	0.01704	0	0
6	0	0	0	0.0142	0	0
7	0	0	0	0.03176	0	0
8	0	0	0	0.03006	0	0
9	0	0	0	0	0	0
10	0	0	0	0.02545	0	0
Average	0.001532	0	0	0.016279	0	0

APPENDIX H12A: Solution for The Number of Patient (NQ) In Brigade Separate Station's Surgical Operation Unit Bed Queue of The Existing and Proposed System Under Increased Arrival Rates

	EXISTING SYSTEM NUMBER OF PATIENT (NQ) IN BRIGADE SEPARATE STATION'S SURGICAL OPERATION UNIT BED QUEUE			PROPOSED SYSTEM NUMBER OF PATIENT (NQ) IN BRIGADE SEPARATE STATION'S SURGICAL OPERATION UNIT BED QUEUE		
Replication Number	First Scenario	Second Scenario	Third Scenario	First Scenario	Second Scenario	Third Scenario
1	0	0.42185	0.00597	0	1	0.00563
2	0	0.33879	0.03519	0	1	0.06733
3	0	0.26849	0.0921	0	0	0.04488
4	0	0.40203	0.29954	0	0	0.03423
5	1	0.32162	0.25658	0	0	0.02772
6	0	0.32417	0.21879	0	0	0.0231
7	0	0.34084	0.36744	0	0	0.03517
8	0	0.3311	0.32181	0	0	0.09172
9	0	0.30517	0.28776	0	0	0.06153
10	0	0.54642	0.25898	0	0	0.07337
Average	0.255465	0.360048	0.214416	0	0	0.048468

APPENDIX H13A: Solution for The Number of Patient (NQ) In Brigade 30 Bed Hospital's Emergency and Normal Surgical Operation Surgery Queue of The Proposed System Under Increased Arrival Rates

	PROPOSED SYSTEM NUMBER OF PATIENT (NQ) IN BRIGADE 30 BED HOSPITAL'S EMERGENCY SURGICAL OPERATION UNIT SURGERY QUEUE			PROPOSED SYSTEM NUMBER OF PATIENT (NQ) IN BRIGADE 30 BED HOSPITAL'S NORMAL SURGICAL OPERATION UNIT SURGERY QUEUE		
Replication Number	First Scenario	Second Scenario	Third Scenario	First Scenario	Second Scenario	Third Scenario
1	0	0	0	0	0	0
2	0	0	0	0	0	0
3	0	0	0	0	0	0
4	0	0	0	0	0	0
5	0	0	0	0	0	0
6	0	0	0	0	0	0
7	0	0	0	0	0	0
8	0	0	0	0	0	0
9	0	0	0	0	0	0
10	0	0	0	0	0	0
Average	0.029524	FALSE	0	0.044451	0	0

APPENDIX H14A: Solution for The Number of Patient In Brigade 30 Bed Hospital's Emergency and Normal Surgical Operation Unit Bed Queue of The Proposed System Under Increased Arrival Rates

	PROPOSED SYSTEM NUMBER OF PATIENT (NQ) IN BRIGADE 30 BED HOSPITAL'S EMERGENCY SURGICAL OPERATION UNIT BED QUEUE			PROPOSED SYSTEM NUMBER OF PATIENT (NQ) IN BRIGADE 30 BED HOSPITAL'S NORMAL SURGICAL OPERATION UNIT BED QUEUE		
Replication Number	First Scenario	Second Scenario	Third Scenario	First Scenario	Second Scenario	Third Scenario
1	0	1	0	0	0	1
2	0	0	0	0	0	1
3	0	0	0	0	0	0
4	0	0	0	0	0	0
5	0	0	0	0	0	0
6	0	1	0	0	0	0
7	0	0	0	0	0	0
8	0	0	0	0	0	0
9	0	0	0	0	1	0
10	0	0	0	0	1	1
Average	0.022972	0	0	0	0	0

APPENDIX I. FIGURES OF SCENARIOS UNDER INCREASED ARRIVAL RATE

1. Time in Queue for Doctor of Second Battalion

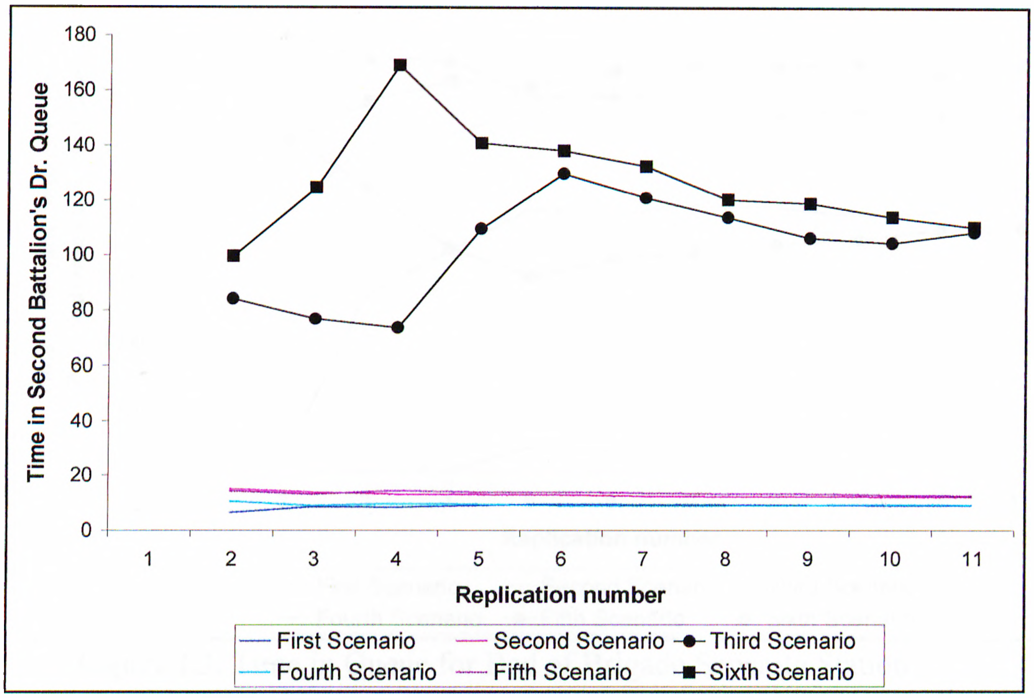


Figure I.1. Time in Queue for Doctor of Second Battalion

2. Time in Queue for Bed of Brigade Separate Station Medical Treatment Unit

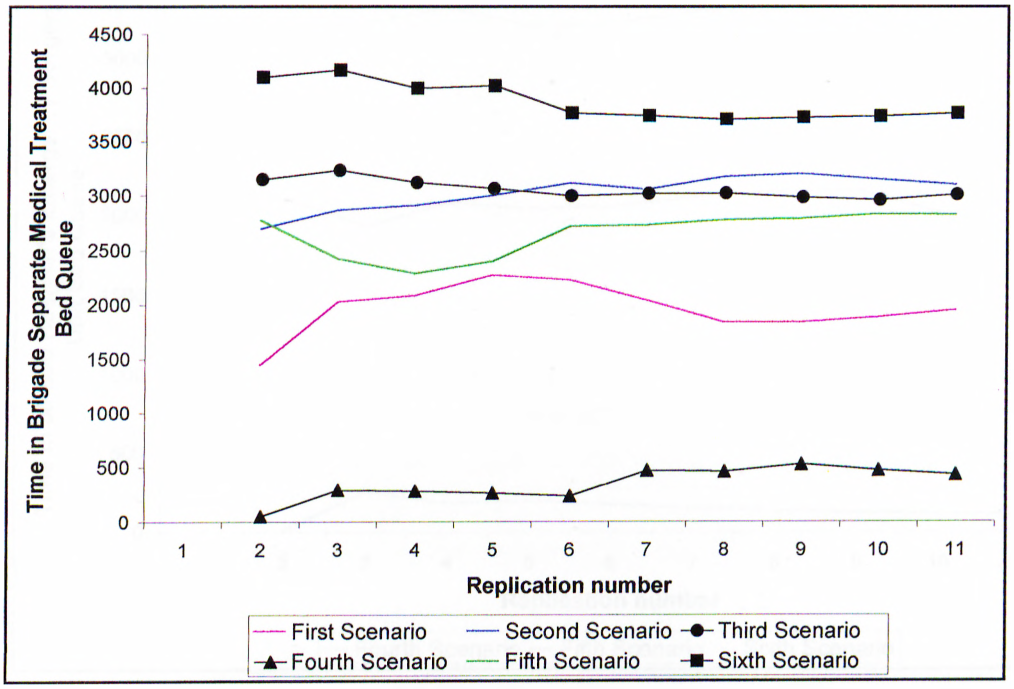


Figure I.2. Time in Queue for Bed of Brigade Separate Station Medical Treatment Unit

3. Time in Queue for Bed of Brigade Separate Station Psychotherapy Unit

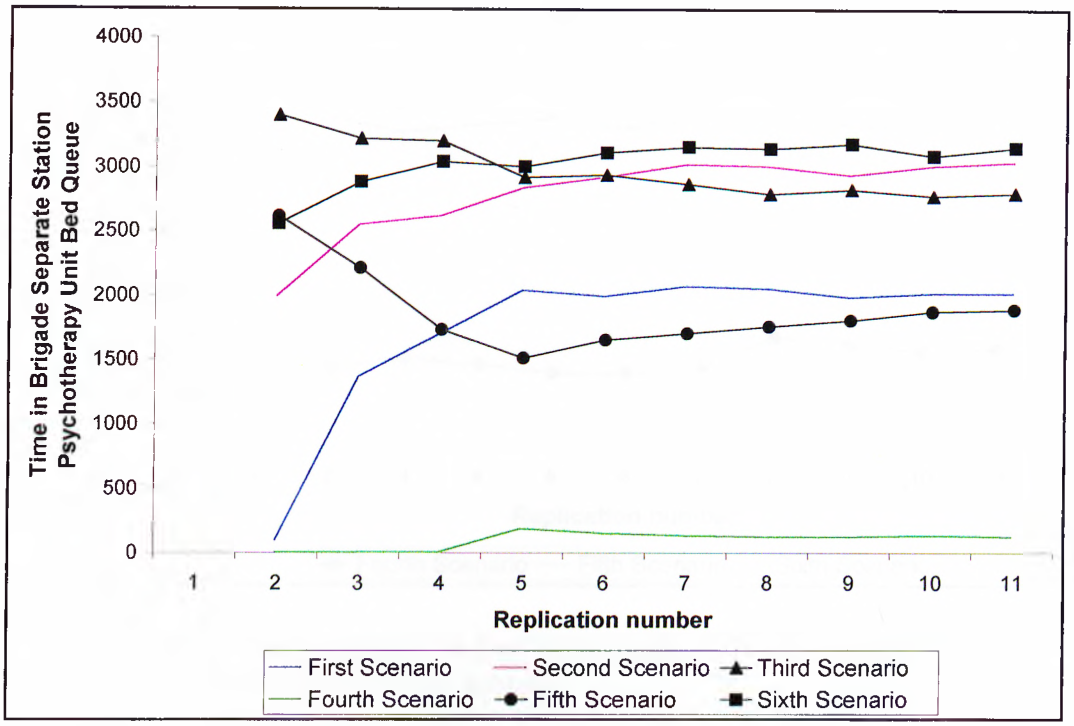


Figure I.3. Time in Queue for Bed of Brigade Separate Station's Psychotherapy Unit

4. Time In Queue for Bed of Brigade 30-Bed Hospital's Emergency Surgical Operation Unit of Proposed System

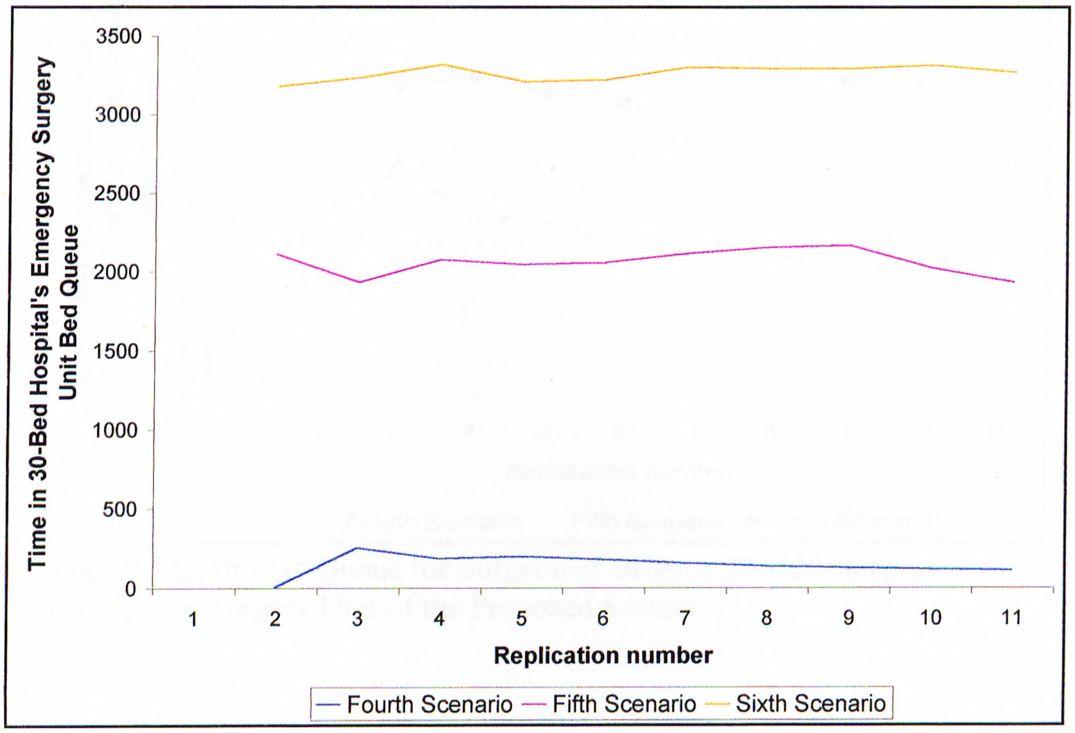


Figure I.4. Time in Queue for Bed of Brigade 30-Bed Hospital's Emergency Surgical Operation Unit of Proposed System

5. **Time in Queue for Bed of Brigade 30-Bed Hospital Normal Surgery Unit of the Proposed System**

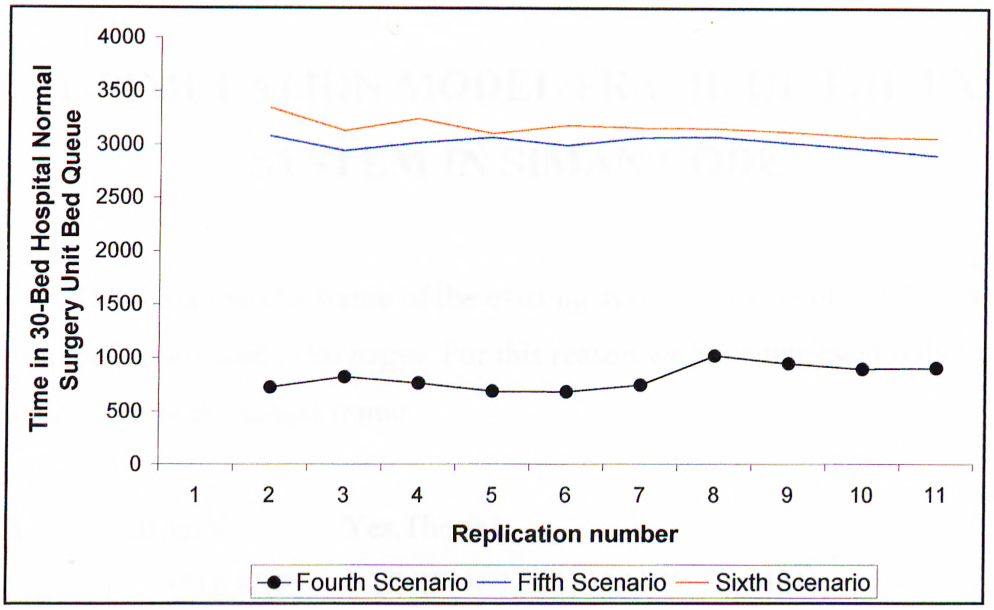


Figure I.5. Time in Queue for Bed of Brigade 30-Bed Hospital Normal Surgery Unit of the Proposed System

6. **Time in Queue for Surgeon of Brigade 30-Bed Hospital Emergency Surgery Unit of the Proposed System**

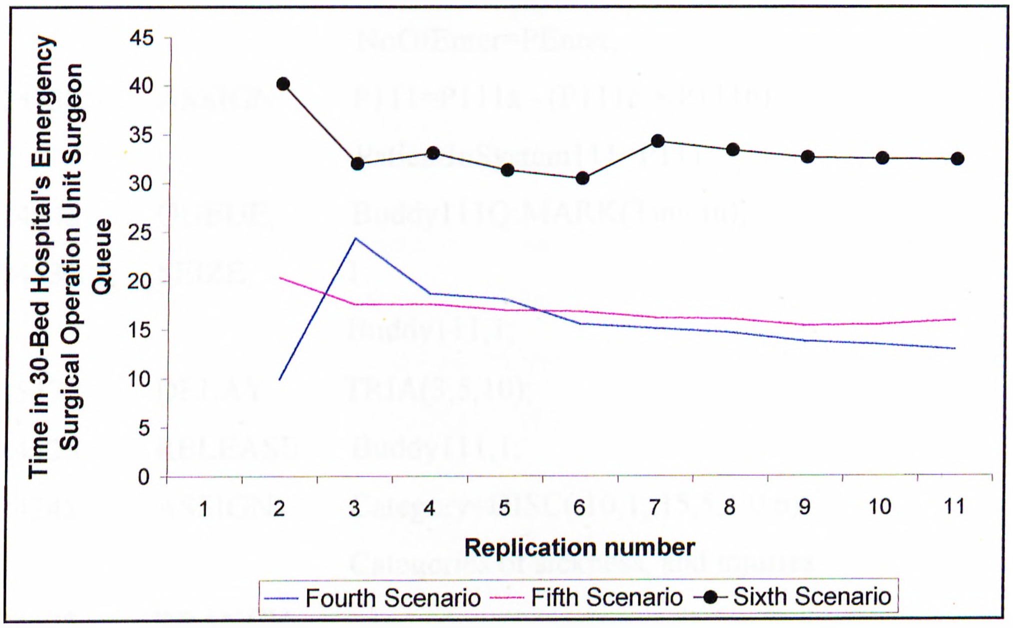


Figure I.6. Time in Queue for Surgeon of Brigade 30-Bed Hospital Emergency Surgery Unit of the Proposed System

APPENDIX J

THE SIMULATION MODEL FRAME OF THE EXISTING SYSTEM IN SIMAN CODE

The Siman model frame of the existing system consists of 2547 lines of writing and it can be represented in 80 pages. For this reason we have represent only first three pages as a sample of the model frame.

```
0$          BEGIN,        Yes,Thesis1;
Dutty111      CREATE,     1:UNIF(460,500):MARK(TimeIn1);
                          Casualty occurs
2389$       ASSIGN:       Casualty=111;
2414$       ASSIGN:       P111a=P111a+1:
                          NoOfEnter111=P111a:
                          PEnter=PEnter+1:
                          NoOfEnter=PEnter;
2413$       ASSIGN:       P111=P111a - (P111c + P111b):
                          PatientInSystem111=P111;
2454$       QUEUE,        Buddy111Q:MARK(TimeIn);
2453$       SEIZE,        1:
                          Buddy111,1;
2547$       DELAY:        TRIA(3,5,10);
2452$       RELEASE:      Buddy111,1;
2424$       ASSIGN:       Category=DISC(.10,1,.15,5,1.0,6);
                          Categories of sickness, and injuries
2467$       BRANCH,        1:
                          If,Category==1,Specialist111a,Yes:
                          If,Category==5,Specialist111b,Yes:
                          If,Category==6,ToAidman11,Yes;
```

```
Specialist111a TALLY:   Time In SystemDutty,INTERVAL(TimeIn1),1;
2410$        ASSIGN:     P111c=P111c+1:
                         NoOfHealthy111=P111c:
                         PDutty=PDutty+1:
                         NoOfHealthy=PDutty:NEXT(Dutty111);

Specialist111b TALLY:   Time In SystemDead,INTERVAL(TimeIn1),1;
2411$        ASSIGN:     P111b=P111b+1:
                         NoOfDead111=P111b: NEXT(NoOfDead);

NoOfDead     TALLY:     Time In SystemDead,INTERVAL(TimeIn1),1;
2081$        ASSIGN:     PDead=PDead+1:
                         NoOfDead=PDead;
2083$        ASSIGN:     PIS=PEnter - (PDead + PDutty):
                         PatientInSystem=PIS;
2082$        DISPOSE;

ToAidman111  QUEUE,   Aidman111Q;
2546$        SEIZE,      1:
                         Aidman111,1;
2458$        DELAY:
                  TRIA(Minimum(Category),Mode(Category),Maximum(Category));
2457$        RELEASE:    Aidman111,1;
2384$        ASSIGN:     Category=DISC(.10,1,.15,5,1.0,6);
                         Categories of sickness, and injuries
2383$        BRANCH,     1:
                         If,Category==1,Specialist111a,Yes:

                         If,Category==5,Specialist111b,Yes:
                         If,Category==6,LitterTeam111,Yes;
LitterTeam111 ASSIGN:  M1=Enter111;
```

```
2545$       QUEUE,        LitterTeam111Q,1;
2544$       REQUEST,      1:LitterTeam111,1800,Enter111;
2543$       DELAY:        1.0;
2542$       TRANSPORT:  LitterTeam111,Platoon111CasualtyNest,1800;


5$        STATION,       Platoon121CasualtyNest;
6$        DELAY:         2.0;
7$        FREE:          LitterTeam121;
8$        QUEUE,         Platoon121CasualtyNestQ:MARK(QUETIME);
9$        SEIZE,     1:
                         Specialist121,1;
452$       TALLY:        TIMEIN Platoon121 QUEUE,INT(QUETIME),1;
10$       DELAY:
                  TRIA(Minimum(Category),Mode(Category),Maximum(Category)),;
11$       RELEASE:       Specialist121,1;
470$       TALLY:        Time In Platoon121,INTERVAL(TimeIn),1;
2102$       ASSIGN:      Category=DISC(.15,1,.40,2,.70,3,.92,4,1.0,5);
                         Categories of sickness, and injuries
12$       BRANCH,        1:
                         If,Category==1,Specialist121a,Yes:
                         If,Category==2,Assembly5,Yes:
                         If,Category==3,ToBattalion1b,Yes:
                         If,Category==5,Specialist121b,Yes:
                         If,Category==4,Seperate5,Yes;
Specialist121a TALLY:  Time In SystemDutty,INTERVAL(TimeIn1),1;
1999$       ASSIGN:      P121c=P121c+1:
                         NoOfHealthy121=P121c:
                         PDutty=PDutty+1:
                         NoOfHealthy = PDutty:NEXT(Dutty121);
```

APPENDIX K

EXISTING SYSTEM ARENA Simulation Results

Özgür NUHUT - License #9810739

Summary for Replication 1 of 10

Project: EXISTING SYSTEM **Run execution date : 5/ 4/2000**

Analyst: Ozgur Nuhut **Model revision date: 17/ 2/2000**

Replication ended at time : 14400.0

TALLY VARIABLES

Identifier	Average	Half Width	Minimum	Maximum	Observations
TIMEIN Company1Enginee	.00000	(Insuf)	.00000	.00000	50
Time In Army Hospital	7606.0	(Insuf)	4682.9	10867.	14
Time In Company3Engine	11.813	(Insuf)	9.7223	15.577	37
TIMEIN Company3Enginee	.00000	(Insuf)	.00000	.00000	37
TimeIn LitterTeam13	5.3750	(Insuf)	4.7500	5.5000	6
TimeIn Ambulance11	4.7586	(Insuf)	4.4375	8.4456	60
TimeIn Ambulance22	4.8118	(Insuf)	4.4375	7.5556	78
TimeIn Ambulance33	4.6745	(Insuf)	4.4375	5.5137	35
TimeIn Ambulance13a	4.1819	(Insuf)	4.0843	4.7012	34
TimeIn Helicopter1	4.2242	(Insuf)	4.0938	5.7821	83
TIMEIN Platoon121 QUEU	.00000	(Insuf)	.00000	.00000	41
TIMEIN Platoon332 QUEU	.00000	(Insuf)	.00000	.00000	17
Time In Cmp System11	24.297	(Insuf)	19.174	32.661	39
Time In Cmp System22	25.681	(Insuf)	18.289	37.535	54
Time In Cmp System33	26.443	(Insuf)	18.597	35.581	26
TimeIn ESrgBed	1276.5	(Insuf)	25.950	3288.7	19
Time In SSrg System	7172.1	(Insuf)	1870.3	12282.	39
Time In Army System	11544.	(Insuf)	8252.3	13399.	14
Time In Btn System1	49.758	3.5523	23.181	127.67	470
TIMEIN Platoon1Tow QUE	.00000	(Insuf)	.00000	.00000	59
TIMEIN Company1AirDefe	.00000	(Insuf)	.00000	.00000	58
Time In Company2Ordnan	10.742	(Insuf)	7.9745	14.329	37
TimeIn Ambulance12	4.7395	(Insuf)	4.4375	7.4968	57
TimeIn Ambulance23	4.7536	(Insuf)	4.4375	8.1578	66

TimeIn Ambulance12a	4.1662	(Insuf)	4.0843	4.1687	34
TimeIn Helicopter2	4.2877	(Insuf)	4.0938	7.5621	81
TimeIn Ambulance23a	4.1757	(Insuf)	4.0843	4.4617	30
TIMEIN Platoon122 QUEU	.00000	(Insuf)	.00000	.00000	29
TIMEIN Platoon123 QUEU	.00000	(Insuf)	.00000	.00000	36
TIMEIN Platoon22Slh QU	.00000	(Insuf)	.00000	.00000	35
TIMEIN Platoon333 QUEU	.00000	(Insuf)	.00000	.00000	16
TIMEIN Platoon33Slh QU	.00000	(Insuf)	.00000	.00000	18
Time In Cmp System12	24.143	(Insuf)	18.378	36.695	40
Time In Cmp System23	25.133	(Insuf)	18.504	36.631	41
Time In Btn System2	47.926	2.4656	22.294	124.57	494
TIMEIN Company1Kh QUEU	.00000	(Insuf)	.00000	.00000	16
Time In 30BedNormalSur	3098.8	(Insuf)	2338.5	3943.4	8
TIMEIN Company21 QUEUE	.12049	(Insuf)	.00000	5.1811	43
TIMEIN Company22 QUEUE	1.3299	(Insuf)	.00000	8.6230	54
TimeIn Ambulance13	4.6863	(Insuf)	4.4375	6.4682	53
TimeIn Ambulance11a	4.1657	(Insuf)	4.0843	4.1687	28
TimeIn Helicopter3	4.2046	(Insuf)	4.0938	4.8810	51
TimeIn Ambulance33a	4.1645	(Insuf)	4.0843	4.1687	20
TimeIn Ambulance22a	4.1667	(Insuf)	4.0843	4.1687	42
TIMEIN Platoon11Slh QU	.00000	(Insuf)	.00000	.00000	37
Time In Cmp System13	26.383	(Insuf)	17.703	38.624	40
TIMEIN Therapist QUEUE	.13125	(Insuf)	.00000	20.166	219
Time In Btn System3	48.046	(Insuf)	21.605	120.34	201
Time In 400Bed Hospita	6999.6	(Insuf)	4419.7	9781.7	217
Time In Company2Engine	12.108	(Insuf)	9.9665	15.028	56
TIMEIN Company23 QUEUE	1.2896	(Insuf)	.00000	11.311	41
TIMEIN Company2Tank QU	.00000	(Insuf)	.00000	.00000	127
TimeIn Ambulance32a	4.1622	(Insuf)	4.0843	4.1687	13
TimeIn Ambulance21a	4.1661	(Insuf)	4.0843	4.1687	33
TIMEIN Platoon231 QUEU	.00000	(Insuf)	.00000	.00000	38
TIMEIN Platoon232 QUEU	.00000	(Insuf)	.00000	.00000	28
Time In SMdcSystem	3973.4	(Insuf)	1744.8	6359.8	55
Time In Company1Ordnan	10.627	(Insuf)	7.9811	14.362	48
Time In Company1AirDef	10.757	(Insuf)	8.1614	14.192	58
Time In Company1Kh	10.312	(Insuf)	8.3573	12.787	16
Time In Company31	13.981	(Insuf)	10.821	18.001	8
TimeIn Ambulance31a	4.1546	(Insuf)	4.0843	4.1687	6
TIMEIN Platoon311 QUEU	.00000	(Insuf)	.00000	.00000	11
TIMEIN Platoon233 QUEU	.00000	(Insuf)	.00000	.00000	28
TIMEIN NSrgBed QUEUE	.00000	(Insuf)	.00000	.00000	14
TIMEIN ESrgBed QUEUE	.00000	(Insuf)	.00000	.00000	10
Time In SThr System	2986.4	(Insuf)	1775.0	3867.5	30
Time In SepMed	3930.2	(Insuf)	1724.5	6301.3	55
Time In Company1Artill	10.858	(Insuf)	8.0144	14.327	197
Time In Company21	15.477	(Insuf)	10.366	24.552	43
Time In Company32	18.175	(Insuf)	13.203	25.233	14
Time In Company2Kh	10.992	(Insuf)	9.3038	13.399	13
TIMEIN Platoon312 QUEU	.00000	(Insuf)	.00000	.00000	15
TIMEIN Platoon313 QUEU	.00000	(Insuf)	.00000	.00000	11
Time In SepThr	2942.8	(Insuf)	1755.5	3826.0	30
Time In Inside System	--	--	--	--	0
TIMEIN Company1Artille	.00000	(Insuf)	.00000	.00000	197
Time In Company11	14.963	(Insuf)	9.8965	25.639	39
Time In Company22	16.666	(Insuf)	10.338	28.873	54

Time In Company33	17.140	(Insuf)	10.579	25.474	26
Time In Company3Kh	11.024	(Insuf)	8.4449	13.157	17
TIMEIN Platoon2Tow QUE	.00000	(Insuf)	.00000	.00000	72
TIMEIN Platoon131 QUEU	.00000	(Insuf)	.00000	.00000	40
TIMEIN Platoon23Slh QU	.00000	(Insuf)	.00000	.00000	28
TimeIn NSrgBed	2976.4	(Insuf)	2238.3	3766.1	8
TIMEIN Company1Ordnanc	.00000	(Insuf)	.00000	.00000	48
Time In Civilian Hospi	6959.9	(Insuf)	6406.8	7513.1	2
Time In Company1Engine	11.865	(Insuf)	9.5150	15.857	50
Time In Company12	15.094	(Insuf)	10.285	29.300	40
Time In Company23	16.224	(Insuf)	10.143	25.278	41
TIMEIN Company3AirDefe	.00000	(Insuf)	.00000	.00000	33
TIMEIN Company3Ordnanc	.00000	(Insuf)	.00000	.00000	18
Time In InsideHospital	--	--	--	--	0
TIMEIN Platoon12Slh QU	.00000	(Insuf)	.00000	.00000	28
TIMEIN Platoon132 QUEU	.00000	(Insuf)	.00000	.00000	30
TIMEIN Platoon133 QUEU	.00000	(Insuf)	.00000	.00000	33
TIMEIN Platoon211 QUEU	.00000	(Insuf)	.00000	.00000	32
TIMEIN Surgery1QUEUE	.58067	(Insuf)	.00000	24.640	260
Time In Company13	17.143	(Insuf)	9.9792	30.580	40
TIMEIN Company31 QUEUE	.00000	(Insuf)	.00000	.00000	8
TIMEIN Company32 QUEUE	1.9816	(Insuf)	.00000	11.334	15
TIMEIN Company2Enginee	.00000	(Insuf)	.00000	.00000	56
TimeIn Ambulancea	4.3153	(Insuf)	4.1515	5.4747	134
Time In Platoon131	9.3284	(Insuf)	6.6978	11.721	40
Time In Platoon3Tow	10.582	(Insuf)	8.3415	13.854	31
TIMEIN Platoon212 QUEU	.00000	(Insuf)	.00000	.00000	38
TIMEIN Platoon31Slh QU	.00000	(Insuf)	.00000	.00000	12
TIMEIN Bed1	2731.8	(Insuf)	1514.5	4025.6	55
TIMEIN Surgery1	32.901	(Insuf)	17.133	58.899	260
Time In SepSur	7127.2	(Insuf)	1848.8	12242.	39
TIMEIN Company1Tank QU	.00000	(Insuf)	.00000	.00000	116
Time In Battalion1	31.243	3.5064	10.327	106.94	470
TIMEIN Company33 QUEUE	1.3720	(Insuf)	.00000	9.2119	26
TimeIn Ambulance1	4.7892	(Insuf)	4.6250	6.2019	250
TimeIn Ambulanceb	4.3246	(Insuf)	4.1515	6.3400	122
Time In Platoon121	9.0345	(Insuf)	6.6832	12.775	41
Time In Platoon132	9.0335	(Insuf)	6.7341	11.781	30
Time In Platoon231	8.8914	(Insuf)	6.5842	14.094	38
Time In Platoon2Tow	10.805	(Insuf)	7.9161	13.776	72
TIMEIN Platoon213 QUEU	.00000	(Insuf)	.00000	.00000	32
TIMEIN Bed2	2733.4	(Insuf)	1671.8	3681.9	30
Time In SystemDutty	359.56	(Corr)	3.2040	12466.	1424
Time In 400Bed System	7417.8	(Insuf)	4582.5	14372.	217
Time In Platoon1Tow	10.527	(Insuf)	7.8777	13.884	59
Time In Battalion2	28.892	2.2044	9.8220	101.89	494
Time In Company3AirDef	10.504	(Insuf)	8.0975	13.276	33
Time In Company2Artill	10.731	(Insuf)	7.8975	14.552	173
TIMEIN Company2Artille	.00000	(Insuf)	.00000	.00000	173
TimeIn Ambulance2	4.7893	(Insuf)	4.6250	6.7043	258
TimeIn Ambulancec	4.3438	(Insuf)	4.1515	5.9190	58
Time In Platoon111	9.0306	(Insuf)	6.5886	12.087	43
Time In Platoon122	9.1250	(Insuf)	7.0030	12.565	29
Time In Platoon133	9.4038	(Insuf)	7.2357	12.946	33
Time In Platoon13Slh	8.7719	(Insuf)	6.7117	12.134	31

Time In Platoon221	9.1739	(Insuf)	6.6023	13.001	53
Time In Platoon331	8.6194	(Insuf)	6.7571	10.216	12
Time In Platoon232	9.3514	(Insuf)	7.1915	12.564	28
TIMEIN Platoon321 QUEU	.00000	(Insuf)	.00000	.00000	11
TIMEIN Bed3	2908.6	(Insuf)	1780.5	4130.9	39
Time In 30BedEmrSur	2697.6	(Insuf)	2075.8	3364.4	9
Time In Company1Tank	12.158	(Insuf)	9.6420	15.565	116
Time In Battalion3	29.426	(Insuf)	9.2411	85.374	201
TIMEIN Platoon3Tow QUE	.00000	(Insuf)	.00000	.00000	31
TimeIn Ambulance3	4.7819	(Insuf)	4.6250	5.0141	108
TIMEIN Bed3Q	5284.2	(Insuf)	.00000	11477.	48
TIMEIN Platoon111 QUEU	.00000	(Insuf)	.00000	.00000	43
Time In Platoon112	9.2355	(Insuf)	6.9011	12.389	35
Time In Platoon123	8.9968	(Insuf)	6.3547	12.463	36
Time In Platoon12Slh	8.8152	(Insuf)	6.7309	11.510	28
Time In Platoon211	8.7958	(Insuf)	6.8805	12.025	32
Time In Platoon321	9.1422	(Insuf)	6.7913	11.768	11
Time In Platoon222	9.1181	(Insuf)	6.7703	11.472	32
Time In Platoon332	9.1549	(Insuf)	7.0685	11.257	17
Time In Platoon233	9.3002	(Insuf)	6.7236	12.835	28
Time In Platoon23Slh	9.5525	(Insuf)	6.8978	11.400	28
TIMEIN Platoon322 QUEU	.00000	(Insuf)	.00000	.00000	15
Time In SystemDead	396.02	167.27	3.1547	12847.	1213
TIMEIN Doctor1 QUEUE	9.5195	3.3230	.00000	88.796	471
Time In Company2Tank	12.205	(Insuf)	9.4754	15.359	127
TIMEIN Company3Kh QUEU	.00000	(Insuf)	.00000	.00000	17
TimeIn Ambulance4	4.0918	(Insuf)	4.0468	4.0937	25
TimeIn Inspector1	14.279	.34398	2.7313	28.448	829
TIMEIN Bed2Q	95.477	(Insuf)	.00000	1082.5	39
TIMEIN Company11 QUEUE	.09835	(Insuf)	.00000	2.3826	40
TIMEIN Platoon112 QUEU	.00000	(Insuf)	.00000	.00000	35
TIMEIN Platoon113 QUEU	.00000	(Insuf)	.00000	.00000	32
TIMEIN Platoon13Slh QU	.00000	(Insuf)	.00000	.00000	31
Time In Platoon113	9.3167	(Insuf)	6.3660	11.594	32
Time In Platoon11Slh	9.1851	(Insuf)	6.2542	12.370	37
Time In Platoon311	9.4365	(Insuf)	6.7537	11.967	11
Time In Platoon212	9.4976	(Insuf)	7.1284	12.527	38
Time In Platoon322	8.5563	(Insuf)	6.7696	12.136	15
Time In Platoon223	9.0304	(Insuf)	6.5492	12.579	42
Time In Platoon22Slh	9.1923	(Insuf)	6.4382	12.208	35
Time In Platoon333	9.6188	(Insuf)	6.9122	13.131	16
Time In Platoon33Slh	9.5368	(Insuf)	7.8924	12.515	18
TIMEIN Platoon323 QUEU	.00000	(Insuf)	.00000	.00000	15
TIMEIN Company12 QUEUE	.82850	(Insuf)	.00000	11.280	41
TIMEIN Doctor2 QUEUE	6.2975	1.8942	.00000	51.679	495
Time In Company3Tank	12.351	(Insuf)	9.3734	15.981	56
TIMEIN Company2AirDefe	.00000	(Insuf)	.00000	.00000	65
TIMEIN Company3Artille	.00000	(Insuf)	.00000	.00000	78
TimeIn LitterTeam31	5.1250	(Insuf)	4.7500	5.5000	2
TimeIn 400BedDoctor	18.791	1.5506	2.4225	94.054	476
TIMEIN Bed1Q	1442.3	(Insuf)	.00000	3679.7	67
Time In Platoon312	9.6093	(Insuf)	7.2521	12.057	15
Time In Platoon213	8.9478	(Insuf)	6.3693	11.783	32
Time In Platoon21Slh	9.3459	(Insuf)	7.0913	12.298	37
Time In Platoon323	9.7695	(Insuf)	7.1184	11.846	15

Time In Platoon32Slh	8.8281	(Insuf)	6.7985	11.351	16
TIMEIN Platoon21Slh QU	.00000	(Insuf)	.00000	.00000	37
TIMEIN Platoon32Slh QU	.00000	(Insuf)	.00000	.00000	16
Time In Civilian Syste	13576.	(Insuf)	13179.	13974.	2
TimeIn NBCInspector4	4.5098	.39141	2.0399	16.026	830
TIMEIN Company13 QUEUE	1.3170	(Insuf)	.00000	9.0385	40
TIMEIN Surgery2 QUEUE	.00000	(Insuf)	.00000	.00000	10
Time In Company3Ordnan	11.311	(Insuf)	9.8221	13.274	18
TIMEIN Doctor3 QUEUE	8.4155	(Insuf)	.00000	55.871	202
TIMEIN Doctor4 QUEUE	2.1720	.83251	.00000	30.234	350
TimeIn LitterTeam21	5.4250	(Insuf)	4.7500	5.5000	10
TimeIn LitterTeam32	5.1250	(Insuf)	4.7500	5.5000	2
Time In Platoon313	9.0070	(Insuf)	6.3334	11.620	11
Time In Platoon31Slh	9.2771	(Insuf)	7.2449	12.377	12
TIMEIN Platoon221 QUEU	.00000	(Insuf)	.00000	.00000	53
TIMEIN Platoon222 QUEU	.00000	(Insuf)	.00000	.00000	32
TIMEIN Therapist	30.377	(Insuf)	20.491	39.663	218
Time In 30Bed System	9776.3	(Insuf)	6941.9	12654.	8
TIMEIN Surgery3 QUEUE	1.9708	(Insuf)	.00000	24.426	15
Time In Company2AirDef	10.595	(Insuf)	8.1733	13.919	65
Time In Company3Artill	10.727	(Insuf)	8.3408	13.902	78
TIMEIN Company3Tank QU	.00000	(Insuf)	.00000	.00000	56
TimeIn LitterTeam11	5.4982	(Insuf)	4.7500	6.2295	12
TimeIn LitterTeam22	5.4375	(Insuf)	4.7500	5.5000	12
TimeIn LitterTeam33	5.3750	(Insuf)	4.7500	5.5000	6
TimeIn Ambulance31	4.7487	(Insuf)	4.4375	6.7247	20
TIMEIN Platoon223 QUEU	.00000	(Insuf)	.00000	.00000	42
Time In Cmp System31	23.083	(Insuf)	19.551	27.740	8
TimeIn Recorder4	5.4852	.56555	2.1986	38.987	831
TIMEIN Company2Kh QUEU	.00000	(Insuf)	.00000	.00000	13
TIMEIN Company2Ordnanc	.00000	(Insuf)	.00000	.00000	37
TimeIn LitterTeam12	5.4062	(Insuf)	4.7500	5.5000	8
TimeIn LitterTeam23	5.4318	(Insuf)	4.7500	5.5000	11
TimeIn Ambulance21	4.7361	(Insuf)	4.4375	7.7298	61
TimeIn Ambulance32	4.6795	(Insuf)	4.4375	5.2937	18
TimeIn ArmyDoctor	17.216	(Insuf)	3.0558	53.188	184
TIMEIN Platoon331 QUEU	.00000	(Insuf)	.00000	.00000	12
Time In Cmp System21	25.015	(Insuf)	18.498	33.012	43
Time In Cmp System32	27.087	(Insuf)	22.258	35.273	14

DISCRETE-CHANGE VARIABLES

Identifier	Average	Half Width	Minimum	Maximum	Final Value
PESRGB	.43712	(Insuf)	.00000	1.0000	1.0000
P30NSURARMY	1.2176	(Insuf)	.00000	5.0000	5.0000
PSEPA	416.92	(Corr)	.00000	831.00	831.00
P13A	19.569	(Insuf)	.00000	34.000	34.000
P3AIRDEFENCEA	20.116	(Insuf)	.00000	36.000	36.000
P3TANK	18.024	(Insuf)	.00000	39.000	39.000
P1KH	5.8966	(Insuf)	.00000	11.000	11.000

NQ(1TOWFIRSTAIDPLACEQ)	.00000	(Insuf)	.00000	.00000	.00000
NQ(AMBULANCE18Q)	.00000	(Insuf)	.00000	.00000	.00000
NQ(THERAPISTQ)	.00200	(Insuf)	.00000	1.0000	.00000
NR(NONCOMMISSINEDOFFIC	.00000	(Insuf)	.00000	1.0000	.00000
NT(AMBULANCEA)	.04003	(Insuf)	.00000	1.0000	.00000
NT(AMBULANCE11A)	.00810	(Insuf)	.00000	1.0000	.00000
NT(AMBULANCE110)	.00613	(Insuf)	.00000	1.0000	.00000
NQ(2TOWFIRSTAIDPLACEQ)	.00000	(Insuf)	.00000	.00000	.00000
PESRGC	.00000	(Insuf)	.00000	.00000	.00000
PSEPSUR30	10.446	(Insuf)	.00000	25.000	25.000
PSEPB	2.8296	(Insuf)	.00000	7.0000	7.0000
P23A	13.973	(Insuf)	.00000	30.000	30.000
P13B	.74588	(Insuf)	.00000	1.0000	1.0000
P12A	17.762	(Insuf)	.00000	34.000	34.000
P3AIRDEFENCEB	2.4051	(Insuf)	.00000	5.0000	5.0000
P3ENGINEERA	20.083	(Insuf)	.00000	40.000	40.000
P2ORDNANCEA	18.442	(Insuf)	.00000	39.000	39.000
P2KH	5.6079	(Insuf)	.00000	12.000	12.000
NQ(AMBULANCE19Q)	.00000	(Insuf)	.00000	.00000	.00000
NQ(DOCTOR1Q)	.31137	.14373	.00000	8.0000	.00000
NT(AMBULANCE12A)	.00984	(Insuf)	.00000	1.0000	.00000
NT(AMBULANCE19)	.00451	(Insuf)	.00000	1.0000	.00000
NQ(3ARTILLERYFIRSTAIDP	.00000	(Insuf)	.00000	.00000	.00000
P131	15.689	(Insuf)	.00000	34.000	34.000
PCIVILIANINSIDE	.07985	(Insuf)	.00000	2.0000	2.0000
PINSIDE	1.3930	(Insuf)	.00000	13.000	13.000
PSSRG	126.93	(Insuf)	.00000	252.00	252.00
PSEPC	5.8506	(Insuf)	.00000	13.000	13.000
P33A	8.5834	(Insuf)	.00000	20.000	20.000
P23B	.45884	(Insuf)	.00000	1.0000	1.0000
P22A	20.125	(Insuf)	.00000	42.000	42.000
P13C	6.7402	(Insuf)	.00000	10.000	10.000
P12B	.76312	(Insuf)	.00000	2.0000	2.0000
P11A	20.133	(Insuf)	.00000	40.000	40.000
P3TOW	10.029	(Insuf)	.00000	22.000	22.000
P3AIRDEFENCEC	6.0954	(Insuf)	.00000	10.000	10.000
P3AIRDEFENCE	11.861	(Insuf)	.00000	21.000	21.000
P3ENGINEERB	2.2008	(Insuf)	.00000	3.0000	3.0000
P3KH	6.2392	(Insuf)	.00000	14.000	14.000
P2ORDNANCEB	5.7316	(Insuf)	.00000	11.000	11.000
P231	12.443	(Insuf)	.00000	28.000	28.000
P1ARTILLERY	61.759	(Insuf)	.00000	123.00	123.00
NQ(DOCTOR2Q)	.21688	.06802	.00000	6.0000	2.0000
NR(NONCOMMISSINEDOFFIC	.00000	(Insuf)	.00000	1.0000	.00000
NR(BED3)	8.7985	(Insuf)	.00000	9.0000	9.0000
NT(AMBULANCE13A)	.00984	(Insuf)	.00000	1.0000	.00000
NT(AMBULANCE18)	.00322	(Insuf)	.00000	1.0000	.00000
NQ(3AIRDEFENCEFIRSTAID	.00000	(Insuf)	.00000	.00000	.00000
P121	13.518	(Insuf)	.00000	29.000	29.000
P132	12.216	(Insuf)	.00000	20.000	20.000
P1	129.63	(Corr)	.00000	252.00	252.00
P33B	.19169	(Insuf)	.00000	2.0000	2.0000
P32A	8.6631	(Insuf)	.00000	13.000	13.000
P23C	2.9401	(Insuf)	.00000	6.0000	6.0000
P22B	.00000	(Insuf)	.00000	.00000	.00000

P21A	19.650	(Insuf)	.00000	43.000	43.000
P12C	3.5874	(Insuf)	.00000	5.0000	5.0000
P11B	.76534	(Insuf)	.00000	1.0000	1.0000
P3ORDNANCE	7.2657	(Insuf)	.00000	9.0000	9.0000
P3ENGINEERC	7.5201	(Insuf)	.00000	14.000	14.000
P331	5.8797	(Insuf)	.00000	10.000	10.000
P2TOW	19.717	(Insuf)	.00000	41.000	41.000
P2ORDNANCEC	1.4345	(Insuf)	.00000	6.0000	6.0000
P2ARTILLERYA	100.70	(Insuf)	.00000	202.00	202.00
P232	9.7773	(Insuf)	.00000	20.000	20.000
P221	19.448	(Insuf)	.00000	39.000	39.000
NQ(1ARTILLERYFIRSTAIDP	.00000	(Insuf)	.00000	.00000	.00000
NR(BED2)	6.9320	(Insuf)	.00000	9.0000	9.0000
NT(AMBULANCE17)	.00548	(Insuf)	.00000	1.0000	.00000
NQ(DOCTOR3Q)	.11870	(Insuf)	.00000	6.0000	1.0000
P111	17.436	(Insuf)	.00000	32.000	32.000
P122	9.2655	(Insuf)	.00000	19.000	19.000
P133	12.887	(Insuf)	.00000	26.000	26.000
P2	124.44	(Corr)	.00000	261.00	261.00
P33C	2.1914	(Insuf)	.00000	3.0000	3.0000
P32B	.00000	(Insuf)	.00000	.00000	.00000
P31A	3.6007	(Insuf)	.00000	8.0000	8.0000
P22C	5.0263	(Insuf)	.00000	11.000	11.000
P21B	.29705	(Insuf)	.00000	1.0000	1.0000
P11C	5.4262	(Insuf)	.00000	11.000	11.000
P332	5.5417	(Insuf)	.00000	11.000	11.000
P321	4.8050	(Insuf)	.00000	10.000	10.000
P2ARTILLERYB	13.178	(Insuf)	.00000	26.000	26.000
P233	11.124	(Insuf)	.00000	23.000	23.000
P222	13.139	(Insuf)	.00000	24.000	24.000
P211	13.523	(Insuf)	.00000	27.000	27.000
P134	14.362	(Insuf)	.00000	27.000	27.000
P1TOW	21.501	(Insuf)	.00000	40.000	40.000
NQ(1KHFIRSTAIDPLACEQ)	.00000	(Insuf)	.00000	.00000	.00000
NR(BED1)	11.387	(Insuf)	.00000	12.000	12.000
NT(AMBULANCE16)	.02068	(Insuf)	.00000	1.0000	.00000
NQ(DOCTOR4Q)	.05279	(Insuf)	.00000	2.0000	.00000
P112	10.632	(Insuf)	.00000	24.000	24.000
P123	16.465	(Insuf)	.00000	29.000	29.000
P30A	10.425	(Insuf)	.00000	25.000	25.000
P3	56.105	(Insuf)	.00000	111.00	111.00
P32C	2.7963	(Insuf)	.00000	4.0000	4.0000
P31B	.00000	(Insuf)	.00000	.00000	.00000
P21C	4.2235	(Insuf)	.00000	9.0000	9.0000
P3ENGINEER	10.507	(Insuf)	.00000	23.000	23.000
P333	6.0989	(Insuf)	.00000	13.000	13.000
P322	7.7922	(Insuf)	.00000	13.000	13.000
P311	5.0095	(Insuf)	.00000	9.0000	9.0000
P2ARTILLERYC	32.663	(Insuf)	.00000	66.000	66.000
P234	12.305	(Insuf)	.00000	22.000	22.000
P223	14.307	(Insuf)	.00000	33.000	33.000
P212	14.682	(Insuf)	.00000	27.000	27.000
NT(AMBULANCE15)	.01077	(Insuf)	.00000	1.0000	.00000
NQ(2TANKFIRSTAIDPLACEQ	.00000	(Insuf)	.00000	.00000	.00000
P113	11.873	(Insuf)	.00000	24.000	24.000

P124	12.002	(Insuf)	.00000	23.000	23.000
PIS	488.96	(Corr)	.00000	937.00	937.00
PSMDC	167.13	(Corr)	.00000	340.00	340.00
NR(THERAPIST)	.46034	.04609	.00000	2.0000	1.0000
PNSRG	4.3381	(Insuf)	.00000	14.000	14.000
PSEPARMY	19.832	(Insuf)	.00000	46.000	46.000
P30B	.83089	(Insuf)	.00000	2.0000	2.0000
P400	222.14	(Corr)	.00000	440.00	440.00
P31C	.49795	(Insuf)	.00000	1.0000	1.0000
P3ORDNANCEA	11.521	(Insuf)	.00000	21.000	21.000
P334	6.6909	(Insuf)	.00000	16.000	16.000
P323	4.8619	(Insuf)	.00000	11.000	11.000
P314A	10.829	(Insuf)	.00000	20.000	20.000
P312	5.2777	(Insuf)	.00000	10.000	10.000
P2ORDNANCE	11.627	(Insuf)	.00000	23.000	23.000
P224	13.818	(Insuf)	.00000	27.000	27.000
P213	12.418	(Insuf)	.00000	25.000	25.000
NQ(SURGERY1Q)	.01048	(Insuf)	.00000	2.0000	.00000
NT(AMBULANCE14)	.00225	(Insuf)	.00000	1.0000	.00000
P114	13.306	(Insuf)	.00000	27.000	27.000
PARMYINSIDE	1.3558	(Insuf)	.00000	11.000	11.000
PINSIDEA	1.3930	(Insuf)	.00000	13.000	13.000
PSTHR	106.33	(Insuf)	.00000	215.00	215.00
P30ESUR400	1.0296	(Insuf)	.00000	3.0000	3.0000
P30C	.00000	(Insuf)	.00000	.00000	.00000
P3ORDNANCEB	2.0743	(Insuf)	.00000	6.0000	6.0000
P3TANKA	28.450	(Insuf)	.00000	63.000	63.000
P324A	17.495	(Insuf)	.00000	29.000	29.000
P324	7.3618	(Insuf)	.00000	11.000	11.000
P314B	4.5306	(Insuf)	.00000	7.0000	7.0000
P313A	6.5271	(Insuf)	.00000	14.000	14.000
P313	4.5215	(Insuf)	.00000	10.000	10.000
P2AIRDEFENCE	22.251	(Insuf)	.00000	43.000	43.000
P2ARTILLERY	55.051	(Insuf)	.00000	110.00	110.00
P214A	21.670	(Insuf)	.00000	48.000	48.000
P214	12.320	(Insuf)	.00000	26.000	26.000
NQ(SURGERY2Q)	.00000	(Insuf)	.00000	.00000	.00000
NR(NONCOMMISSINEDOFFIC	.00000	(Insuf)	.00000	1.0000	.00000
NT(AMBULANCE13)	.01712	(Insuf)	.00000	1.0000	.00000
NQ(2KHFIRSTAIDPLACEQ)	.00000	(Insuf)	.00000	.00000	.00000
PCIVILIANA	13.394	(Insuf)	.00000	52.000	52.000
PARMY	57.768	(Insuf)	.00000	181.00	181.00
PARMYA	58.007	(Insuf)	.00000	184.00	184.00
PINSIDEB	.00000	(Insuf)	.00000	.00000	.00000
PNSRGA	4.6813	(Insuf)	.00000	15.000	15.000
PCTG2	132.06	(Insuf)	.00000	264.00	264.00
P400A	230.13	(Corr)	.00000	476.00	476.00
P3ORDNANCEC	2.7725	(Insuf)	.00000	7.0000	7.0000
P3TANKB	5.4581	(Insuf)	.00000	10.000	10.000
P334A	10.772	(Insuf)	.00000	25.000	25.000
P324B	1.3843	(Insuf)	.00000	4.0000	4.0000
P323A	10.644	(Insuf)	.00000	20.000	20.000
P314C	3.8957	(Insuf)	.00000	6.0000	6.0000
P314	3.0278	(Insuf)	.00000	7.0000	7.0000
P313B	1.7007	(Insuf)	.00000	2.0000	2.0000

P312A	8.8551	(Insuf)	.00000	19.000	19.000
P2TANKA	69.799	(Insuf)	.00000	145.00	145.00
P224A	25.674	(Insuf)	.00000	51.000	51.000
P214B	2.4542	(Insuf)	.00000	6.0000	6.0000
P213A	25.535	(Insuf)	.00000	45.000	45.000
P1AIRDEFENCEA	33.352	(Insuf)	.00000	65.000	65.000
P1ENGINEERA	28.476	(Insuf)	.00000	57.000	57.000
P1ARTILLERYA	114.28	(Insuf)	.00000	225.00	225.00
NQ(BED1Q)	8.4766	(Insuf)	.00000	20.000	19.000
NQ(SURGERY3Q)	.00205	(Insuf)	.00000	1.0000	.00000
NQ(AMBULANCEAQ)	1.2436E-04	(Insuf)	.00000	1.0000	.00000
NT(AMBULANCE12)	.01842	(Insuf)	.00000	1.0000	.00000
P114A	21.362	(Insuf)	.00000	46.000	46.000
P400ARMY	.00000	(Insuf)	.00000	.00000	.00000
PCIVILIANB	.00000	(Insuf)	.00000	.00000	.00000
PARMYB	.10706	(Insuf)	.00000	1.0000	1.0000
PINSIDEC	.00000	(Insuf)	.00000	.00000	.00000
PENTER	1482.0	(Corr)	.00000	2924.0	2924.0
PSTHRA	107.35	(Insuf)	.00000	218.00	218.00
PNSRGB	.39377	(Insuf)	.00000	1.0000	1.0000
PCTG3	579.52	(Corr)	.00000	1173.0	1173.0
P30	9.6782	(Insuf)	.00000	23.000	23.000
P400B	4.5529	(Insuf)	.00000	17.000	17.000
P3A	102.28	(Insuf)	.00000	204.00	204.00
PDUTTY	694.77	(Corr)	.00000	1377.0	1377.0
P3TANKC	5.2085	(Insuf)	.00000	14.000	14.000
P334B	1.3066	(Insuf)	.00000	3.0000	3.0000
P333A	10.292	(Insuf)	.00000	21.000	21.000
P324C	9.0442	(Insuf)	.00000	15.000	15.000
P323B	2.6975	(Insuf)	.00000	3.0000	3.0000
P322A	12.987	(Insuf)	.00000	21.000	21.000
P313C	.50198	(Insuf)	.00000	2.0000	2.0000
P312B	2.1899	(Insuf)	.00000	3.0000	3.0000
P311A	7.8144	(Insuf)	.00000	14.000	14.000
P2ENGINEER	22.604	(Insuf)	.00000	39.000	39.000
P2TANKB	9.7720	(Insuf)	.00000	20.000	20.000
P234A	21.308	(Insuf)	.00000	44.000	44.000
P224B	3.6029	(Insuf)	.00000	8.0000	8.0000
P223A	21.589	(Insuf)	.00000	56.000	56.000
P214C	7.1714	(Insuf)	.00000	16.000	16.000
P213B	5.2746	(Insuf)	.00000	7.0000	7.0000
P212A	26.090	(Insuf)	.00000	46.000	46.000
P1AIRDEFENCEB	5.7329	(Insuf)	.00000	11.000	11.000
P1ENGINEERB	3.0512	(Insuf)	.00000	7.0000	7.0000
P1ARTILLERYB	12.018	(Insuf)	.00000	26.000	26.000
P1TANKA	69.905	(Insuf)	.00000	134.00	134.00
NQ(AMBULANCE1Q)	1.5011E-04	(Insuf)	.00000	1.0000	.00000
NQ(BED2Q)	.50395	(Insuf)	.00000	5.0000	5.0000
NT(AMBULANCE11)	.01939	(Insuf)	.00000	1.0000	.00000
NQ(AMBULANCEBQ)	1.9287E-04	(Insuf)	.00000	1.0000	.00000
NT(HELICOPTER3)	.01482	(Insuf)	.00000	1.0000	.00000
P113A	19.441	(Insuf)	.00000	38.000	38.000
P114B	3.0755	(Insuf)	.00000	7.0000	7.0000
P124A	19.387	(Insuf)	.00000	36.000	36.000
PCIVILIAN	13.394	(Insuf)	.00000	52.000	52.000

PCIVILIANC	.00000	(Insuf)	.00000	.00000	.00000
PARMYC	.13494	(Insuf)	.00000	2.0000	2.0000
PSTHRB	.07614	(Insuf)	.00000	1.0000	1.0000
PSMDCA	170.25	(Corr)	.00000	349.00	349.00
PNSRGC	.00000	(Insuf)	.00000	.00000	.00000
NR(ESRGBED)	1.7614	(Insuf)	.00000	5.0000	1.0000
PCTG4	601.13	(Corr)	.00000	1212.0	1212.0
P400C	3.4820	(Insuf)	.00000	19.000	19.000
P3B	10.666	(Insuf)	.00000	22.000	22.000
P2A	238.91	(Corr)	.00000	497.00	497.00
P31	3.1969	(Insuf)	.00000	7.0000	7.0000
P334C	2.9698	(Insuf)	.00000	6.0000	6.0000
P333B	.79850	(Insuf)	.00000	1.0000	1.0000
P332A	12.019	(Insuf)	.00000	23.000	23.000
P323C	3.3822	(Insuf)	.00000	6.0000	6.0000
P322B	1.4005	(Insuf)	.00000	2.0000	2.0000
P321A	8.1340	(Insuf)	.00000	17.000	17.000
P312C	1.6795	(Insuf)	.00000	6.0000	6.0000
P311B	1.5029	(Insuf)	.00000	3.0000	3.0000
P2TANKC	20.131	(Insuf)	.00000	46.000	46.000
P234B	2.9143	(Insuf)	.00000	9.0000	9.0000
P233A	19.082	(Insuf)	.00000	39.000	39.000
P224C	8.5986	(Insuf)	.00000	16.000	16.000
P223B	.61077	(Insuf)	.00000	4.0000	4.0000
P222A	25.081	(Insuf)	.00000	46.000	46.000
P213C	8.1745	(Insuf)	.00000	13.000	13.000
P212B	2.7852	(Insuf)	.00000	4.0000	4.0000
P211A	22.373	(Insuf)	.00000	48.000	48.000
P134A	24.051	(Insuf)	.00000	43.000	43.000
P1TOWA	36.434	(Insuf)	.00000	66.000	66.000
P1ORDNANCE	13.818	(Insuf)	.00000	28.000	28.000
P1AIRDEFENCEC	10.845	(Insuf)	.00000	20.000	20.000
P1ENGINEERC	11.360	(Insuf)	.00000	22.000	22.000
P1ARTILLERYC	40.681	(Insuf)	.00000	76.000	76.000
P1TANKB	9.7531	(Insuf)	.00000	22.000	22.000
NQ(1TANKFIRSTAIDPLACEQ	.00000	(Insuf)	.00000	.00000	.00000
NQ(AMBULANCE11Q)	4.4163E-04	(Insuf)	.00000	1.0000	.00000
NQ(BED3Q)	105.15	(Insuf)	.00000	212.00	212.00
NQ(AMBULANCE2Q)	1.5572E-04	(Insuf)	.00000	1.0000	.00000
NQ(2ARTILLERYFIRSTAIDP	.00000	(Insuf)	.00000	.00000	.00000
NQ(3KHFIRSTAIDPLACEQ)	.00000	(Insuf)	.00000	.00000	.00000
NQ(AMBULANCECQ)	1.7458E-04	(Insuf)	.00000	1.0000	.00000
NT(HELICOPTER2)	.02355	(Insuf)	.00000	1.0000	.00000
P112A	22.510	(Insuf)	.00000	48.000	48.000
P113B	4.2338	(Insuf)	.00000	7.0000	7.0000
P114C	5.2634	(Insuf)	.00000	13.000	13.000
P123A	26.003	(Insuf)	.00000	46.000	46.000
P124B	3.4195	(Insuf)	.00000	6.0000	6.0000
PSMDCB	.77865	(Insuf)	.00000	2.0000	2.0000
PSTHRC	.95819	(Insuf)	.00000	2.0000	2.0000
PSEPTHERAPY400	.00000	(Insuf)	.00000	.00000	.00000
P3C	36.054	(Insuf)	.00000	71.000	71.000
P2B	32.951	(Insuf)	.00000	70.000	70.000
P1A	238.32	(Corr)	.00000	472.00	472.00
P32	6.1729	(Insuf)	.00000	9.0000	9.0000

P21	15.346	(Insuf)	.00000	33.000	33.000
P333C	3.4934	(Insuf)	.00000	7.0000	7.0000
P332B	2.7206	(Insuf)	.00000	5.0000	5.0000
P331A	8.8553	(Insuf)	.00000	18.000	18.000
P322C	3.9927	(Insuf)	.00000	6.0000	6.0000
P321B	1.3010	(Insuf)	.00000	3.0000	3.0000
P311C	1.6005	(Insuf)	.00000	2.0000	2.0000
P2TOWA	45.225	(Insuf)	.00000	90.000	90.000
P234C	6.4700	(Insuf)	.00000	14.000	14.000
P233B	2.1859	(Insuf)	.00000	4.0000	4.0000
P232A	17.359	(Insuf)	.00000	37.000	37.000
P223C	6.8164	(Insuf)	.00000	20.000	20.000
P222B	3.1384	(Insuf)	.00000	5.0000	5.0000
P221A	37.922	(Insuf)	.00000	69.000	69.000
P212C	8.8094	(Insuf)	.00000	15.000	15.000
P211B	4.8706	(Insuf)	.00000	10.000	10.000
P134B	2.4476	(Insuf)	.00000	3.0000	3.0000
P1TOWB	4.2804	(Insuf)	.00000	8.0000	8.0000
P1TANKC	22.542	(Insuf)	.00000	41.000	41.000
NQ(AMBULANCE12Q)	3.4483E-04	(Insuf)	.00000	1.0000	.00000
NR(NONCOMMISSINEDOFFIC	.00000	(Insuf)	.00000	1.0000	.00000
NR(NONCOMMISSINEDOFFIC	.00000	(Insuf)	.00000	1.0000	.00000
NT(HELICOPTER1)	.02413	(Insuf)	.00000	1.0000	.00000
NQ(BRIGADESEPERATESTAT	.00480	(Insuf)	.00000	1.0000	.00000
NQ(3ENGINEERFIRSTAIDPL	.00000	(Insuf)	.00000	.00000	.00000
NR(DOCTOR4)	.35951	.04101	.00000	1.0000	1.0000
NQ(AMBULANCE3Q)	1.6174E-05	(Insuf)	.00000	1.0000	.00000
P111A	28.878	(Insuf)	.00000	54.000	54.000
P112B	4.2609	(Insuf)	.00000	9.0000	9.0000
P113C	3.6720	(Insuf)	.00000	7.0000	7.0000
P122A	20.127	(Insuf)	.00000	36.000	36.000
P123B	3.4388	(Insuf)	.00000	6.0000	6.0000
P124C	4.2064	(Insuf)	.00000	7.0000	7.0000
P133A	24.274	(Insuf)	.00000	46.000	46.000
PSMDCC	2.3867	(Insuf)	.00000	7.0000	7.0000
P2C	81.963	(Insuf)	.00000	166.00	166.00
P1B	29.624	(Insuf)	.00000	63.000	63.000
P33	6.5815	(Insuf)	.00000	15.000	15.000
P22	15.239	(Insuf)	.00000	31.000	31.000
P11	14.237	(Insuf)	.00000	28.000	28.000
P3TOWA	13.745	(Insuf)	.00000	33.000	33.000
P3ARTILLERY	31.984	(Insuf)	.00000	57.000	57.000
P3KHA	7.6393	(Insuf)	.00000	18.000	18.000
P332C	4.1824	(Insuf)	.00000	8.0000	8.0000
P331B	1.6962	(Insuf)	.00000	3.0000	3.0000
P321C	2.2993	(Insuf)	.00000	4.0000	4.0000
P2TOWB	4.7738	(Insuf)	.00000	9.0000	9.0000
P233C	5.9403	(Insuf)	.00000	12.000	12.000
P232B	3.3438	(Insuf)	.00000	6.0000	6.0000
P231A	26.090	(Insuf)	.00000	55.000	55.000
P222C	9.0448	(Insuf)	.00000	17.000	17.000
P221B	5.0350	(Insuf)	.00000	9.0000	9.0000
P211C	4.3079	(Insuf)	.00000	11.000	11.000
P134C	7.3876	(Insuf)	.00000	13.000	13.000
P1TOWC	10.840	(Insuf)	.00000	18.000	18.000

P1ENGINEER	.00000	(Insuf)	.00000	.00000	.00000
NQ(1AIRDEFENCEFIRSTAID	.00000	(Insuf)	.00000	.00000	.00000
NQ(AMBULANCE13Q)	1.2583E-04	(Insuf)	.00000	1.0000	.00000
NQ(AMBULANCE13AQ)	3.6981E-05	(Insuf)	.00000	1.0000	.00000
NR(NONCOMMISSINEDOFFIC	.01989	(Insuf)	.00000	1.0000	.00000
NQ(BRIGADESEPERATESTAT	.01390	(Insuf)	.00000	1.0000	.00000
NQ(2ENGINEERFIRSTAIDPL	.00000	(Insuf)	.00000	.00000	.00000
NR(DOCTOR3)	.13988	(Insuf)	.00000	1.0000	1.0000
NQ(AMBULANCE4Q)	.00000	(Insuf)	.00000	.00000	.00000
P111B	4.3559	(Insuf)	.00000	8.0000	8.0000
P112C	7.7744	(Insuf)	.00000	15.000	15.000
P121A	26.690	(Insuf)	.00000	60.000	60.000
P122B	4.2748	(Insuf)	.00000	7.0000	7.0000
P123C	6.3813	(Insuf)	.00000	11.000	11.000
P132A	23.153	(Insuf)	.00000	38.000	38.000
P133B	2.7277	(Insuf)	.00000	5.0000	5.0000
NQ(ESRGBEDQ)	.00000	(Insuf)	.00000	.00000	.00000
P30NSUR400	.93097	(Insuf)	.00000	3.0000	3.0000
P1C	79.474	(Insuf)	.00000	157.00	157.00
P23	10.737	(Insuf)	.00000	23.000	23.000
P12	13.559	(Insuf)	.00000	27.000	27.000
P3TOWB	2.4311	(Insuf)	.00000	6.0000	6.0000
P3KHB	.00000	(Insuf)	.00000	.00000	.00000
P331C	1.5779	(Insuf)	.00000	5.0000	5.0000
P2TOWC	20.930	(Insuf)	.00000	40.000	40.000
P2AIRDEFENCEA	41.258	(Insuf)	.00000	80.000	80.000
P2ENGINEERA	34.505	(Insuf)	.00000	65.000	65.000
P2KHA	6.6116	(Insuf)	.00000	15.000	15.000
P232C	4.5334	(Insuf)	.00000	11.000	11.000
P231B	7.5485	(Insuf)	.00000	12.000	12.000
P221C	13.721	(Insuf)	.00000	21.000	21.000
P1ORDNANCEA	25.732	(Insuf)	.00000	54.000	54.000
P1AIRDEFENCE	17.039	(Insuf)	.00000	34.000	34.000
NR(NONCOMMISSINEDOFFIC	.01631	(Insuf)	.00000	1.0000	1.0000
NQ(1ENGINEERFIRSTAIDPL	.00000	(Insuf)	.00000	.00000	.00000
NQ(AMBULANCE14Q)	.00000	(Insuf)	.00000	.00000	.00000
NQ(AMBULANCE12AQ)	.00000	(Insuf)	.00000	.00000	.00000
NR(NONCOMMISSINEDOFFIC	.00000	(Insuf)	.00000	1.0000	.00000
NR(DOCTOR2)	.35459	.03961	.00000	1.0000	1.0000
NR(SURGERY3)	.09043	(Insuf)	.00000	1.0000	.00000
NT(AMBULANCE4)	.00710	(Insuf)	.00000	1.0000	.00000
P111C	7.3435	(Insuf)	.00000	14.000	14.000
P121B	5.5035	(Insuf)	.00000	11.000	11.000
P122C	6.9231	(Insuf)	.00000	10.000	10.000
P131A	26.650	(Insuf)	.00000	55.000	55.000
P132B	4.9906	(Insuf)	.00000	9.0000	9.0000
P133C	8.8400	(Insuf)	.00000	15.000	15.000
PSSRGA	131.39	(Insuf)	.00000	260.00	260.00
NR(NSRGBED)	2.1389	(Insuf)	.00000	6.0000	6.0000
P30ESURARMY	2.3664	(Insuf)	.00000	5.0000	5.0000
PSEP400	127.38	(Insuf)	.00000	263.00	263.00
PSEP	408.29	(Corr)	.00000	811.00	811.00
P13	12.292	(Insuf)	.00000	23.000	23.000
P3TOWC	1.5745	(Insuf)	.00000	6.0000	6.0000
P3ARTILLERYA	47.101	(Insuf)	.00000	85.000	85.000

P3KHC	1.4001	(Insuf)	.00000	4.0000	4.0000
P2AIRDEFENCEB	3.4917	(Insuf)	.00000	7.0000	7.0000
P2ENGINEERB	2.6520	(Insuf)	.00000	8.0000	8.0000
P2KHB	.00000	(Insuf)	.00000	.00000	.00000
P231C	6.4564	(Insuf)	.00000	15.000	15.000
P1ORDNANCEB	4.3103	(Insuf)	.00000	9.0000	9.0000
P1KHA	11.095	(Insuf)	.00000	20.000	20.000
P132C	6.3690	(Insuf)	.00000	9.0000	9.0000
NR(NONCOMMISSINEDOFFIC	.01717	(Insuf)	.00000	1.0000	1.0000
NQ(AMBULANCE15Q)	.00000	(Insuf)	.00000	.00000	.00000
NQ(HELICOPTER1Q)	2.1735E-04	(Insuf)	.00000	1.0000	.00000
NQ(AMBULANCE110Q)	.00000	(Insuf)	.00000	.00000	.00000
NQ(AMBULANCE11AQ)	.00000	(Insuf)	.00000	.00000	.00000
NR(DOCTOR1)	.34340	.03772	.00000	1.0000	1.0000
NR(SURGERY2)	.03031	(Insuf)	.00000	1.0000	.00000
NQ(3ORDNANCEFIRSTAIDPL	.00000	(Insuf)	.00000	.00000	.00000
NT(AMBULANCE3)	.03585	(Insuf)	.00000	1.0000	.00000
P121C	8.0129	(Insuf)	.00000	20.000	20.000
P131B	4.6304	(Insuf)	.00000	8.0000	8.0000
P400CIVILIAN	13.449	(Insuf)	.00000	53.000	53.000
PSSRGB	1.9748	(Insuf)	.00000	4.0000	4.0000
PESRG	5.2577	(Insuf)	.00000	9.0000	9.0000
PSEPSUR400	2.5188	(Insuf)	.00000	6.0000	6.0000
P3ARTILLERYB	2.3089	(Insuf)	.00000	6.0000	6.0000
P2AIRDEFENCEC	15.682	(Insuf)	.00000	30.000	30.000
P2ENGINEERC	9.5024	(Insuf)	.00000	19.000	19.000
P2KHC	1.0037	(Insuf)	.00000	3.0000	3.0000
P1ORDNANCEC	7.8854	(Insuf)	.00000	18.000	18.000
P1KHB	1.4965	(Insuf)	.00000	3.0000	3.0000
P1TANK	37.851	(Insuf)	.00000	71.000	71.000
NQ(1ORDNANCEFIRSTAIDPL	.00000	(Insuf)	.00000	.00000	.00000
NQ(AMBULANCE16Q)	.00000	(Insuf)	.00000	.00000	.00000
NT(AMBULANCE2)	.08565	.01339	.00000	1.0000	.00000
NQ(2AIRDEFENCEFIRSTAID	.00000	(Insuf)	.00000	.00000	.00000
NQ(2ORDNANCEFIRSTAIDPL	.00000	(Insuf)	.00000	.00000	.00000
NQ(HELICOPTER2Q)	5.6986E-04	(Insuf)	.00000	1.0000	.00000
NT(AMBULANCEC)	.01732	(Insuf)	.00000	1.0000	.00000
P131C	6.5562	(Insuf)	.00000	13.000	13.000
PDUTTYA	9.4676	(Insuf)	.00000	34.000	34.000
PSSRGC	2.5057	(Insuf)	.00000	4.0000	4.0000
NR(SURGERY1)	.59405	.06559	.00000	2.0000	.00000
PESRGA	5.5947	(Insuf)	.00000	10.000	10.000
NQ(NSRGBEDQ)	.00000	(Insuf)	.00000	.00000	.00000
PTERSEP400	98.882	(Insuf)	.00000	201.00	201.00
PDEAD	296.26	(Corr)	.00000	602.00	602.00
P3ARTILLERYC	12.921	(Insuf)	.00000	22.000	22.000
P2TANK	40.105	(Insuf)	.00000	79.000	79.000
P1KHC	3.9971	(Insuf)	.00000	6.0000	6.0000
NQ(AMBULANCE17Q)	.00000	(Insuf)	.00000	.00000	.00000
NT(AMBULANCE1)	.08300	.00887	.00000	1.0000	.00000
NQ(3TANKFIRSTAIDPLACEQ	.00000	(Insuf)	.00000	.00000	.00000
NQ(3TOWFIRSTAIDPLACEQ)	.00000	(Insuf)	.00000	.00000	.00000
NQ(HELICOPTER3Q)	6.6759E-05	(Insuf)	.00000	1.0000	.00000
NT(AMBULANCEB)	.03645	(Insuf)	.00000	1.0000	.00000

APPENDIX L

Welch Approach

The Confidence interval is used to answer two questions:

1. How large is the mean difference, and how precise is the estimator of mean difference?
2. Is there a significant difference between the two systems. This question will lead to one of three possible conclusions:

a. If the confidence interval for $\mu 1- \mu 2$ is totally to the left zero, as shown in figure L1 (a) , then there is strong evidence for the hypothesis that

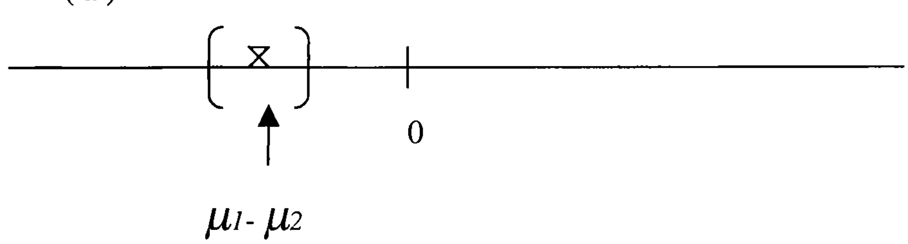
$\mu 1- \mu 2 < 0$, or equivalently $\mu 1 < \mu 2$

b. If the confidence interval for $\mu 1- \mu 2$ is totally to the right of zero, as shown in figure L1 (b), then there is strong evidence that

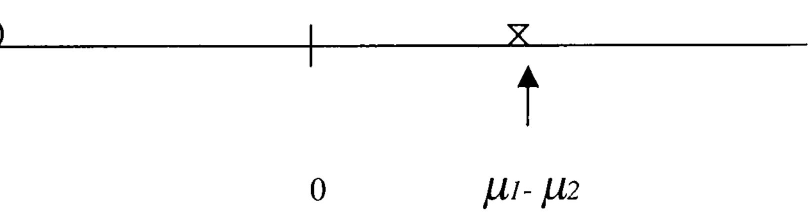
$\mu 1- \mu 2 > 0$, or equivalently $\mu 1 > \mu 2$

c. If the confidence interval for $\mu 1- \mu 2$ contains zero, as shown iğn figure L1 (c), then, based on the data at hand, there is no strong statistical ecidence is that one system design is better than the other.

(a)



(b)



(c)

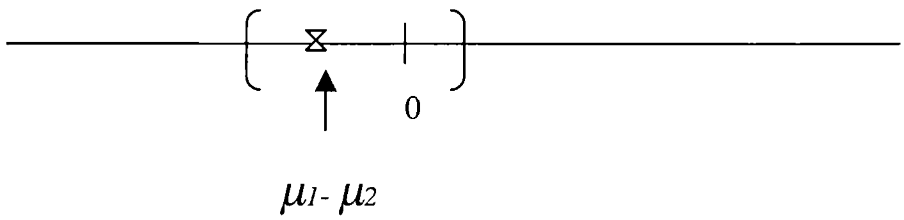


Figure L1. Three possible confidence intervals when comparing two systems.

This approach to forming a confidence interval requires that the *Xj*'s be independent of the *Yj*'s. However, n_1 and n_2 can be different.

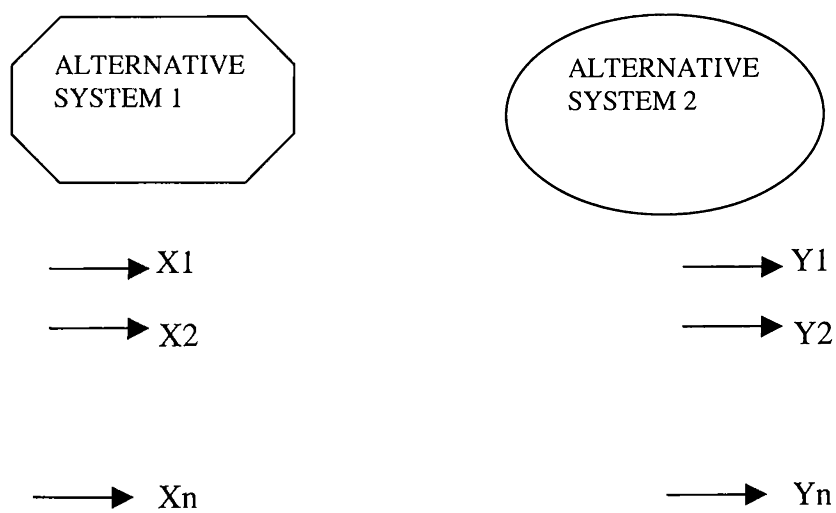


Figure L2. Comparison of two alternative systems

If variances of the alternatives are not equal $\left(\sigma_X^2 \neq \sigma_Y^2\right)$, then confidence interval is

$$(\bar{X}-\bar{Y}) \pm t_{f,1-\frac{\alpha}{2}}\left[\frac{S_X^2}{m}+\frac{S_Y^2}{n}\right]^{1/2}$$

where $\overline{X}$ is the mean of averages of observations from the first alternative simulation output at replication n

$\overline{Y}$ is the mean of averages of observations from the second alternative simulation output at replication n

S_x^2 is the variance of the first alternative

S_y^2 is the variance of the second alternative

m = n = 10 is the sample size (or number of replication

and where $(\bar{X} - \bar{Y})$ is the point estimator of μ_x and μ_y

$\left[\frac{SX^2}{m} + \frac{SY^2}{n} \right]^{1/2}$ is the standard error or variance of the estimator

$$\hat{f} = \frac{\left[\frac{SX^2}{m} + \frac{SY^2}{n} \right]^{1/2}}{\left[\frac{SX^2}{m} \right]^2 \Big/ m-1 + \left[\frac{SY^2}{n} \right]^2 \Big/ n-1}$$ is the degree of freedom.

BIOGRAPHY

Özgür Nuhut is a graduate student in the Department of Industrial Engineering at Bilkent University. His research interests include simulation and modelling of military systems.

Graduating with a Bachelor of Science degree in Management Science from the Turkish Military Academy in 1990, he began his career as a Field Artillery officer. He has also received certificate in System Engineering from Military Academy. He is now a captain and a battery commander in a Battalion of Turkish Army.

Captain Nuhut's military experience spans command positions as a line officer from platoon to company level. He has served in a variety of joint and combined assignments. He served two years in Gebze, one year as a commander of liasion platoon for a regiment(alay), and the other year as an observer for an artillery battalion. He has also served for two years in Siverek and Şırnak, 4 months as a commander of liasion platoon and 20 months as an observer and as an executive officer for an artillery battery (company). He has served for 3 other years at the School of Artillery as a platoon commander of officer's basic training course in Polatlı. He also has been in Pakistan for 3 months for mid career course. He has been temporarily appointed to Bosnian Artillery Battery as an administrative commander for 8 months during this 3 year service period.